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ABSTRACT

A project was undertaken to develop a remedial academic curriculum and materials that would help disadvantaged students gain the basic mathematics skills necessary to succeed in an electronics program. Major activities of the project included development of a bibliography of currently available math resource books with materials appropriate for use with disadvantaged students, a school staff evaluation of the current electronics program with regard to students' math needs, evaluation of the remedial program currently in place for electronics students, and development of a student handbook that includes a step-by-step process for solving electronics-related algebra problems. Appendixes (the major portion of the report) include a discussion of the scope and sequence of electronics-related math concepts and processes; vocabulary, metric relationships, and mathematical formulas for electronic-related math; guidelines for using a three-prong model to plan instruction of electronics-related math; and a bibliography. (MN)

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TITLE PAGE

Final Report

Project No. 85 AXY (054) NB

MATH BASIC SKILLS MODULE FOR DISADVANTAGED ELECTRONIC STUDENTS

Curriculum Development Project
Conducted
Public Law 94-482

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SUMMARY OF THE REPORT

The major objective of the project was:

To develop a remedial academic curriculum and materials which directly relate to and reinforce the program goals and student learning objectives of the Electronics program at Lake Washington Vocational Technical Institute.

The major activities included:

1. Development of a Bibliography of currently available math resource books which are appropriate for use with disadvantaged electronic students.
2. A staff evaluation of the current electronics program in regards to the math needs of the students.
3. An evaluation of the remedial math program currently in place for electronics students.
4. Development of a Student Handbook which provides the step by step process for solving electronics related alegraic solutions.

The Electronics staff concluded from their evaluation data that the primary difficulty of disadvantaged electronics students was their inability to understand the processes for achieving the solutions to algebraic problems. As students enroll on an open entry basis, with varying abilities, individualizing math became a problem.

Teachers and students recommended the development of a student handbook which detailed the process for solutions. Using such a handbook the student could self-check his own process in order to identify and correct errors in process.

This project provided the opportunity for the development of such a handbook. It is recommended that the Student Handbook for Algebra Processes and Solutions become available to all Electronic students that have difficulty with the algebra funtions as they relate to electronics.

The results and accomplishments of this project include the production of the Student Handbook for Algebraic processes, a bibliography of appropriate reference books, a pre-test post-test, a scope and sequence of mathematical concepts, a model for developing instructional plans, vocabulary list, and math charts.

The evaluation of this project led to the establishment of a mini course available to disadvantaged electronics students, using the materials developed in this course.

BODY OF THE REPORT

Statement of Problem

A. Why there is a need

Latest statistics collected at Lake Washington Vocational Technical Institute indicate that 37 percent of the students who enroll in vocational training are in some way academically disadvantaged. Other VTIs and skills centers in the state report similar findings. Many of these students come to training as refugees with no experience in a technical world and little command of the English language. Other students because of language learning disabilities have difficulty following written and/or oral directions. Students also enroll who have dropped out of school because of poor basic academic skills, poor attendance or inability to see the advantages an education can provide in life.

There are few vocational programs which do not require some knowledge of academics; reading instructions, manuals, directions; writing work orders, invoices, requisitions; operating machines and equipment which require an understanding of math functions; communicating with fellow employees, customers, and the general public by phone, mail, or in person.

All of these skills which are desirable in an employee have a base in the academic realm. The worker who has not mastered them is put at a definite disadvantage in the world of work.

Many vocational instructors came to teaching via industry. Few of them have the background or time to help students with basic academic skills. The expect students to be able to read and follow directions, use basic measuring devices accurately and communicate so that they can be understood. Working with these disadvantaged students in the regular program can be a source of concern, frustration, and discouragement to teacher and student alike.

In many training facilities, disadvantaged students are assigned to resource room teachers who have been trained in remediation of academic skills. Very often these teachers have little or no background in vocational training. Students are placed in remediation to struggle once again with the very kinds of materials they have failed to comprehend in the past.

OBJECTIVES

To develop a remedial academic curriculum and materials which directly relate to and reinforce the program goals and student learning objectives of the Electronics program at Lake Washington Vocational Technical Institute.

SUB-OBJECTIVES

1. To define a scope for a remedial academic Electronics curriculum at Lake Washington Vocational Technical Institute which shall use the goals and objectives of the Electronics program as a base. No such curriculum now exists.

2. To determine sequence of student learning objectives for the remedial program which directly relates to the sequence already established in the Electronics program at Lake Washington Vocational Technical Institute.

3. To develop student learning objectives for remedial development of Electronics students which are appropriate to and reinforcing of the Electronics program. No such objectives presently exist.

4. To gather up-to-date teacher resources that shall be used to develop learning activities for the above objectives. No such resources are presently available.

5. To develop/acquire a bibliography that can be used as teacher/student reference. No such bibliography presently exists at Lake Washington Vocational Technical Institute.

6. To design an evaluation instrument that will be used by students and teachers to evaluate this program. No such instrument exists which can be used to evaluate this program.

The staff of four electronics instructors and their program supervisor met weekly for 10 sessions in order to:

1. Gather information on the characteristics of the students.
2. Investigate and evaluate current methods of teaching to the needs of electronics students deficient in math skills.
3. Discuss methods and materials for instruction of math that would be appropriate and reinforce the current Electronics programs.
4. To determine the scope of the remedial math program for electronics students.

Appropriate information gathered at these meetings has been incorporated into the structure of the Electronics program.

The electronics staff identified the development of the Student Handbook for algebra processes and solutions as the appropriate focus of development. The handbook and accompanying text will be available to students. If a large enough group needs remedial assistance, a special class will be offered, using the Student Handbook and accompanying text as source materials. If only a few students need help, it can be used for a self-paced, self-corrected individual education plan.

Preliminary evaluation indicates that the Student Handbook allows students to work independently, reduces frustration, saves time, and reinforces learning. Preliminary evaluation indicates that academically disadvantaged students have been given the opportunity to experience academic growth which is meaningful and related to vocational goals. A follow-up evaluation will be conducted at the end of the 85-86 school year.

The project will be disseminated to interested secondary and Vocational Technical Institute instructors through the Vocational Directors in NEVAC and at appropriate workshops and seminars.

elec/report

APPENDIX

Scope and Sequence of Electronics Related Math Concepts and Processes page 2

Vocabulary for Electronics related Math page 7

Using the 3-Prong Model to plan instruction of Electronics related to Math (Examples) page 17

Metric Relationships for Electronics Related Math page 34

Electronics Technician Survey Formulas used in Electronics page 43

Bibliography page 86

Student Handbook: under separate cover

Electronics Math Processes and Solutions for Basic Mathematics for Electronics Cook/Adams/Dell under separate cover

SCOPE AND SEQUENCE OF ELECTRONICS RELATED MATH

CONCEPTS AND PROCESSES

SCOPE AND SEQUENCE OF ELECTRONICS RELATED MATH CONCEPTS AND PROCESS

INTRODUCTION

Understanding electronics is based upon understanding the mathematics that correlates to the electronic functions. Electronics instructors need to understand the sequence of math concepts in order to sequence their instruction of electronic concepts that relate to math skills.

Academically disadvantaged students have a long hisotry of negative experiences with math. In addition, a vocational institute is likely to have students who have been out of the school environment for many years. For both groups of students the use of a mathematically correct vocabulary can be threatning. Many such students learn algebra, trigonometry, and calculus as those functions are interrelated to electronics functions. Experience has shown that math anxiety increases when the instructor identifies a math function as "algebra" "trigonometry" or "calculus" and math anxiety is reduced if these mathematical terms are not used to describe a math function that relates to an electronic function.

The following outline that identifies the sequence of math concepts uses mathematical terms in order to properly identify a function to the instructor. It is suggested that the instructor avoid the use of the categorical terms of Algebra I, Algebra II, Trigonometry, and Calculus when they introduce a new concept to electronic students.

SCOPE AND SEQUENCE

I. Pre-Algebra

A. Numbers and number systems.

1. Integers
   a. positive
   b. negative

2. Fractions

3. Irrational numbers

4. Imaginary numbers

B. Exponents roots and powers of ten

1. Exponents
   a. positive integral exponents
   b. negative exponents
   c. fractional exponents

2. Scientific notation

II. Algebra I

A. Basic laws and axioms

B. Variables and expressions

III. Algebra II

A. Polynomials and operations

1. Add
2. Subtract
3. Multiply
4. Divide

B. Factoring

1. Simple division
2. Perfect squares
3. Difference of two squares
4. Synthetic division

IV. Equations and graphing

A. Simple linear

1. Solving by algebraic methods

2. Solving by graphical methods

B. Systems of linear equations

C. Quadratic equations

D. Introduction to matrix methods

E. Numerical methods

V. Functions and Functional notation

A. Dependent and independent variables

B. Functons of Conic sections

1. Parabola

2. Hyperbola

3. Circle

4. Ellipse

VI. Log and Exponential functions

A. Transcendental Functions - (logx, ln(x), e^x)

B. Semi-log and log-log graphs

C. Generation of T. functions by computer, using infinite series

VII. Trigonometry

1. Angular measure
   a. deg
   b. rad

2. Triangles and pythagorean theorem

3. Polar cord. system - (with imag. J-axis)

4. Circular functions
   a. sine
   b. cos
   c. tan
   d. inverse circular functions

VIII. Calculus

A. Review of functions

B. Rate of change of a function

1. Average rates and slopes

2. Instantaneous rates

C. Limits

D. Derivatives of functions

1. Definition

2. Calculation

3. Applications

E. Integrals

F. Differential Equations

el/sequence

VOCABULARY

FOR

ELECTRONICS RELATED MATH

VOCABULARY

In order to apply mathematical concepts to electronics, a student must be familiar with a basic electronics/mathematics vocabulary

Alternating Current	(AC) An electric current that reverses direction at regularly recurring intervals.
Ammeter	An instrument for measuring electric current.
Ampere	(A) A unit of electrical current.
Amplifier	A device used to increase the strength of an input current or voltage signal so that the output is stronger, but has the same features as the input.
Bandwidth	A group or band of frequencies which surround a center frequency.
Base Current	(I_b) The current through the base of a transistor.
Base Voltage	(E_b) The voltage present at the base of a transistor.
Battery	Two or more cells in one case producing a pure DC voltage.
Beta	The current gain of a common emitter transistor circuit.
Capacitance	(C) The property of a capacitor that permits the storage of electrostatic energy. The unit of capacitance is the farad.
Capacitive Reactance	(X_c) The opposition to an alternating current due to capacitance. The capacitive reactance is expressed in ohms.
Capacitor	An electrical device consisting of two conducting surfaces which are oppositely charged and are separated by thin layers of dielectric material.

Circuit	The conduction part, or a system of conducting parts, through which an electrical current passes.
Coil	(See Inductor)
Collector Current	(I_c) The current through the collector of a transistor.
Collector Voltage	(E_c) The voltage present at the collector of a transistor.
Component	An individual part or device such as a resistor, a transistor or an integrated circuit.
Conductance	(G) The ability of material to carry electrical current. It is measured in siemens.
Current	(I) The transfer of an electric charge through a material. Current is measured in amperes.
Current Gain	The ratio of output current to input current.
Cycle	A complete positive and a complete negative alternation of voltage or current.
Cycles per second	(See Hertz)
Diode	A two-terminal solid-state, or tube, device that conducts current in one direction but not in the other.
Direct Current	(DC) An electrical current in which there is a continuous transfer of charge in one direction only.
Emitter Current	(I_e) The current through the emitter of a transistor.
Emmitter Voltage	(E_e) The voltage present at the emitter of a transistor.

Etch	Removing the conductive material on a printed circuit board using chemical action.
Farad	(F) The unit of capacitance.
Field Effect Transistor	(FET) A type of transistor with a very high input impedance.
Filament	The heating element used in vacuum tubes and light bulbs.
Filter	A circuit or device which blocks some frequencies and passes others.
Frequency	(f) The number of complete cycles in a unit of time. It is expressed in hertz.
Fuse	An electrical safety device that is constructed of wire or fusible material. It melts and opens an electrical circuit when the rated amount of current is exceeded.
Henry	(H) The unit for inductance.
Hertz	(H_z) The unit for frequency.
Impedance	(Z) The total opposition to an alternating current. Included are inductive reactance, capacitive reactance, and resistance. It is expressed in ohms.
Inductance	(L) The property of an alternating current circuit to induce an electromotive force by varying the current. It is expressed in henrys.
Inductive Reactance	(X_1) The opposition of an inductor to an alternating current. It is expressed in ohms.
Inductor	An electrical device that acts upon another or is itself acted upon by induction. As the conductor is wound into a spiral or coil the inductive intensity increases.

Integrated Circuit	(IC) A combination of devices and elements in a miniature self-contained package. Usually these IC's are designed to perform a particular function.
Kirchhoff's Current Law	The sum of the currents entering a junction equals the sum of the currents leaving that junction.
Kirchhoff's Voltage Law	The sum of the voltage drops around a closed loop equals the applied voltage.
Load	The resistance connected across the output of a circuit.
Mutual Inductance	(M or L_M) The condition that exists in a circuit when the positions of the two inductors cause magnetic lines of force from one inductor to link the turns of the other.
Neon Lamp	A glass lamp filled with neon gas.
Ohm	A unit of resistance.
Ohm's Law	Current is directly proportional to the voltage and inversely proportional to the resistance.
Ohmmeter	A meter used to measure resistance in ohms.
Operational Amplifier	(Op-Amp) An amplifier that can be used for many applications. Some of these are mathematical, such as addition, subtraction, and multiplication.
Oscillator	A circuit for producing alternating current power at a frequency determined by the values of certain constants in the circuit.
Oscilloscope	A test instrument using a cathode ray tube (CRT) to display signal patterns.

Parallel Circuit	A method of connecting a circuit so the current has two or more paths to follow.
Peak	The point of maximum voltage, current, or power during a cycle.
Peak-to-Peak	The voltage, current, or power measured from positive peak to negative peak.
Period	The length of time for one cycle to occur.
Photoconductive Cell	A resistor with a higher resistance in the dark and a lower resistance when exposed to light.
Photovoltaic Cell	A cell that generates a voltage when struck by light.
Potentiometer	A three-terminal variable resistor.
Power	(P) The rate of doing work. It is expressed in watts.
Power Gain	The ratio of output power to input power.
Reactance	(X) Opposition to alternating current due to inductance and/or capacitance. It is expressed in ohms.
Relay	An electromechanical switch.
Resistance	(R) The opposition a material has to the flow of charge. It is expressed in ohms.
Resistor	A device that opposes the flow of an electric current. It is used for protection, operation, or current control.
Rheostat	A two-terminal variable resistor.
rms Voltage	(E_{rms}) The DC equivalent of an AC sine wave.

Schematic	The diagram of an electrical or electronic circuit.
Series Circuit	A method of connecting a circuit so the current has one path to follow.
Solar Cell	(See Photovoltaic Cell)
Solder	An alloy of lead and tin which melts at a low temperature. It is used to join metallic surfaces.
Thermistor	A resistor that changes resistance when exposed to temperature change.
Tolerance	The amount of deviation from a specific value that is allowed.
Transformer	An electromagnetic device using induction to increase or decrease alternating current voltage.
Transistor	An electronic device consisting of a small block of semiconductors with a minimum of three electrodes.
Tube	An electronic device consisting of a sealed glass or metal envelope. Electrons move thorugh the tube in a vacuum.
Volt	(V) A unit of electrical potential or pressure.
Voltage	(E) The electromotive force or electrical pressure. It is expressed in volts.
Voltage Gain	The ratio of output voltage to input voltage.
Voltmeter	A meter used to measure voltage.
Watt	(W) A unit of power.
Wattmeter	A meter used to measure power.
Zener Diode	A diode that maintains a constant breakdown voltage.

SI METRICS STYLE GUIDE

SI metrics is derived from the French name Le Système International d'Unites. The metric unit names are already in accepted practice. SI metrics attempts to standardize the names and usages so that students of metrics will have a universal knowledge of the application of terms, symbols, and units.

The English system of mathematics (used in the United States) has always had many units in its weights and measures tables which were not applied to everyday use. For example, the pole, perch, furlong, peck, and scruple are not used often. These measurements, however, are used to form other measurements and it has been necessary to include the measurements in the tables. Including these measurements aids in the understanding of the orderly sequence of measurements greater or smaller than the less frequently used units.

The metric system also has units that are not used in everyday application. Only by learning the lesser-used units is it possible to understand the order of the metric system. SI metrics, however, places an emphasis on the most frequently used units.

In using the metric system and writing its symbols, certain guidelines are followed. For the student's reference, some of the guidelines are listed.

1. In using the symbols for metric units, the first letter is capitalized only if it is derived from the name of a person.

SAMPLE: UNIT	SYMBOL	UNIT	SYMBOL
metre	m	Newton	N (named after Sir Isaac Newton)
gram	g	degree Celsius	°C (named after Anders Celsius)

EXCEPTION: The symbol for litre is L. This is used to distinguish it from the number one (1).

2. Prefixes are written with lowercase letters.

SAMPLE:	PREFIX	UNIT	SYMBOL
	centi	metre	cm
	milli	gram	mg

EXCEPTIONS:

PREFIX	UNIT	SYMBOL
tera	metre	Tm (used to distinguish it from the metric tonne, t)
giga	metre	Gm (used to distinguish it from gram, g)
mega	gram	Mg (used to distinguish it from milli, m)

3. Periods are not used in the symbols. Symbols for units are the same in the singular and the plural (no "s" is added to indicate a plural).

SAMPLE: 1 mm **not** 1 mm. 3 mm **not** 3 mms

4. When referring to a unit of measurement, symbols are not used. The symbol is used only when a number is associated with it.

SAMPLE:			
The length of the room is expressed in metres.	**not**	The length of the room is expessed in m. (The length of the room is 25 m is correct)

5. When writing measurements that are less than one, a zero is written before the decimal point.

SAMPLE: 0.25 m **NOT** .25 m

6. Separate the digits in groups of three, counting from the decimal point to the left and to the right. A space is left between the groups of digits.

SAMPLE: 5 179 232 mm **NOT** 5,179,232 mm 0.566 23 mg
NOT 0.56623 mg 1 346.098 7 L **NOT** 1,346.0987 L

A space is also left between the digits and the unit of measure.

SAMPLE: 5 179 232 mm **NOT** 5 179 232mm

7. Symbols for area measure and volume measure are written with exponents.

SAMPLE: 3 cm^2 **NOT** 3 sq. cm 4 km^3 **NOT** 4 cu. km

8. Metric words with prefixes are accented on the first syllable. In particular, kilometre is pronounced "kill'-o-metre." This avoids confusion with words for measuring devices which are generally accented on the second syllable, such as thermometer (ther-mom'-e-ter) .

USING THE THREE PRONG MODEL

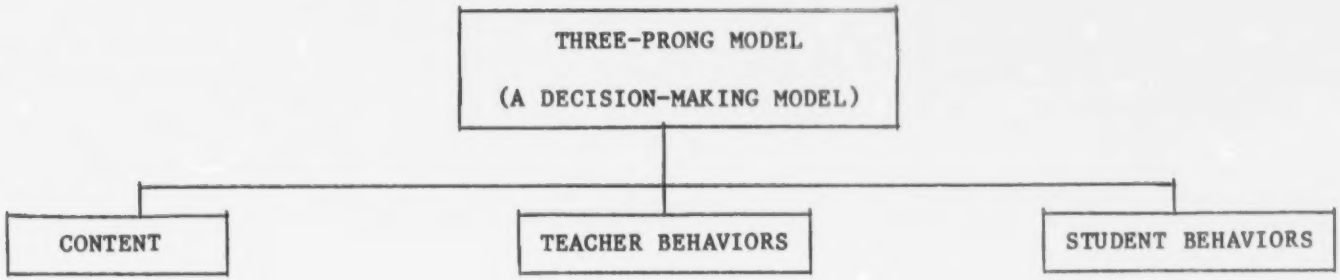
TO PLAN INSTRUCTION OF

ELECTRONICS RELATED MATH

(EXAMPLES)

OBJECTIVE: LEARNER WILL: Demonstrate to a Learning Level of the (Concept or Process)

BY: Student Behavior



In developing a lesson format the teacher analyzes the content as follows:

What to teach	**How** to teach	**Check** for learning
1. Concept 2. Process	1. Delivery	1. What students will be doing during lesson. 2. Proof they have learned
Concept	**Teacher Defines**	**Student Defines**
Definition by critical attributes	1. Defines 2. Gives examples	3. Student defines 4. Discrimination between example and non-example 5. Generate their own examples
Process list steps	1. Model the process 2. Label the steps	1. Have students do it.

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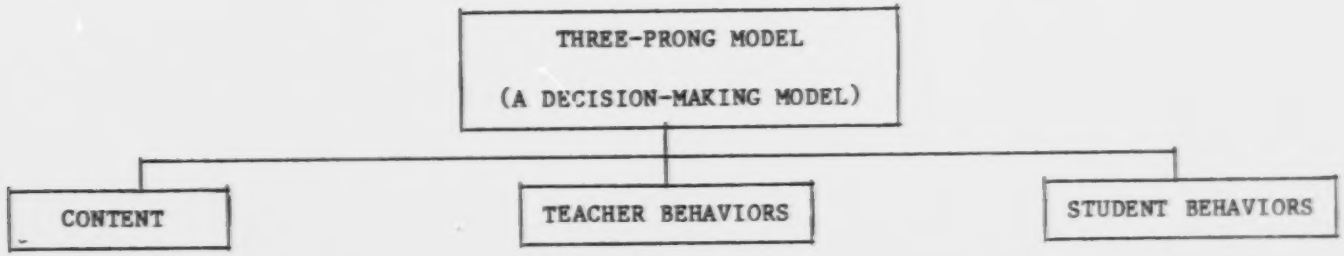
OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the concept of Linear Equations

BY: Defining and giving examples



Examples of content analyzation

I.	Linear equation (concept)	1. Define by critical attribute and give example	1. Students will define 2. Students will give examples

Example

Linear Equations - definition

a. Has this form: AX +BY = C, where A, B, & C are constants.

b. X & Y are to the 1st power

Examples:	Non Examples
1. X + Y = 0	1. $X^2 - Y = 0$
2. 3X - 4Y = 16	2. X1/3 + 2Y = 6
3. .3X + 1/5Y = 36/100	3. $X^3 - 6 = 41$
4. -10X + Y = 2	
5. 2X + 3Y = 1001	
6. X = 2 (B & C = 0)	

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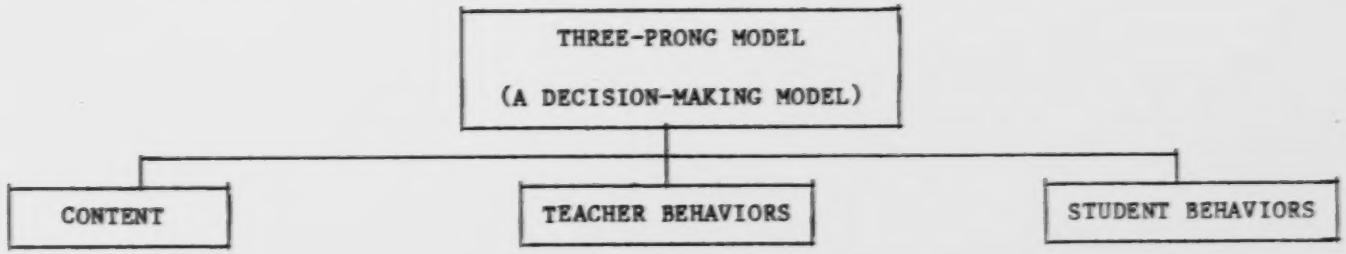
OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of Algebraic Solution

BY: Checking prepared solutions



II. Algebraic solution (process)	1. List steps and work problems on the board	1. Give problems to students and check them

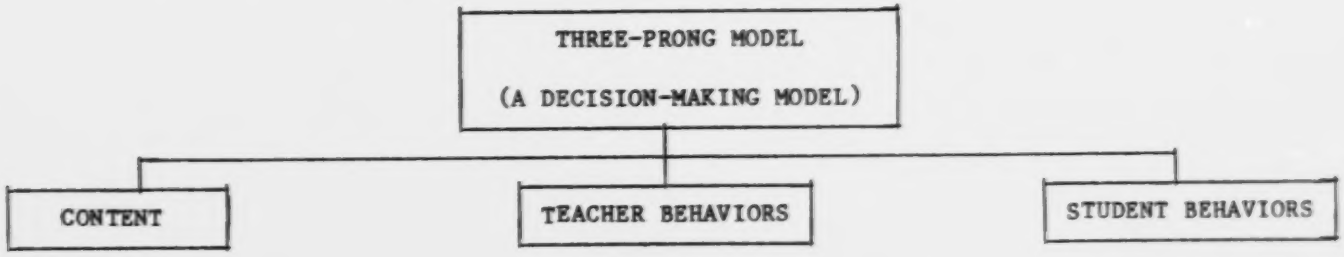
Example

Algebraic solution

1. Solve for Y. - will have form: $Y = \frac{C - AX}{B} = \frac{-A}{B} X + \frac{C}{B}$

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of Graphic Solution

BY: Graphing equations



III. Graphic solution (process)	1. List steps and graph equations on blackboard 2. Assign equations to be graphed by students	1. Students graph equations

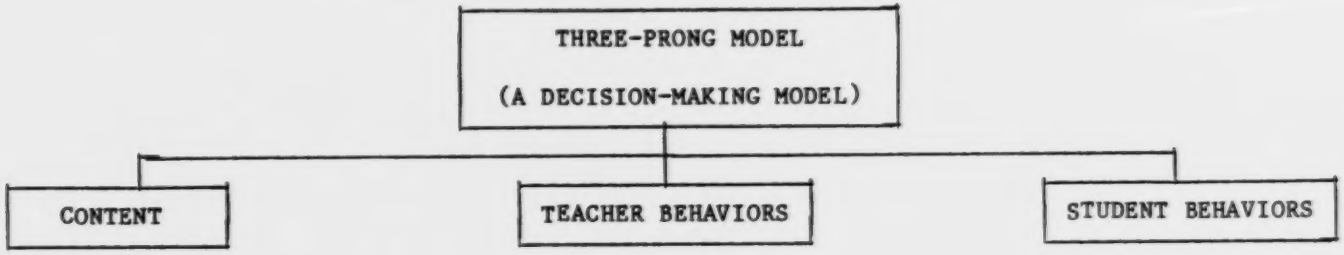
Example

Graphical Solution

1. Set X = 0, & solve for Y.
2. Plot (0, Y)
3. Set Y = 0, & solve for X.
4. Plot (X, 0)
5. Connect the two points.

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the concept of Systems of Equations

BY: Defining and by generating examples



IV.	Systems of equations (concept)	1. Define 2. Give examples	1. Students will define 2. Students generate examples

Examples

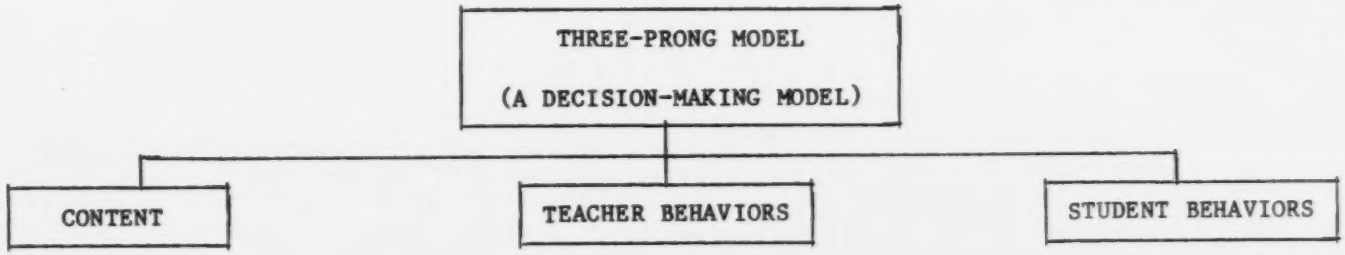
Systems of Equations (linear)

Definition: A set of Equations of the form: $AX + BY = C$
$DX + EY = F$

Examples	Non Examples
1. $2X + 3Y = 0$ $11X - Y = 4$	1. $2X^2 - Y = 4$ $X + Y = 1$
2. $X + Y = 1$ $X = 5$	2. $2X - \frac{1}{Y} = 3$ $2X - 4Y = 0$

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of Substitutions

BY: Working and checking an assigned problem



V.	Substitution (process)	1. List steps 2. Demonstrate process on board	1. Assign problem to students and check

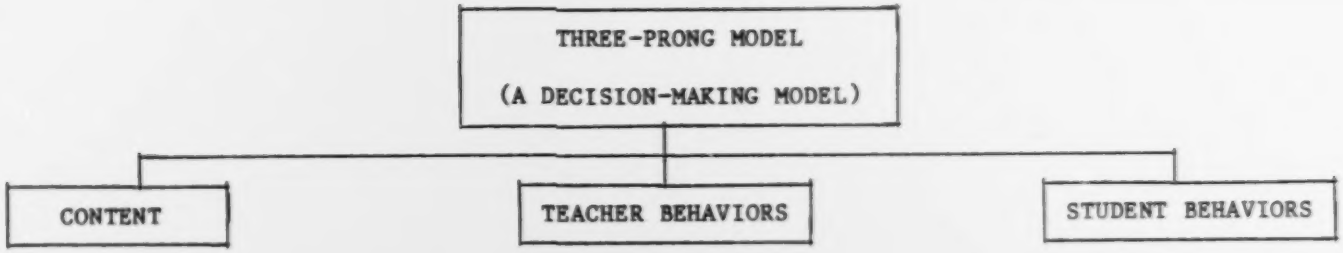
Example

Substitution

1. Solve either equation for either variable
2. Substitute variable (obtained in step 1) into second equation.
3. Solve for remaining variable.
4. Substitute result from step 3 into either equation and solve for remaining variable.

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of adding out

BY: Working and checking a problem



VI.	Adding out (process)	1. List steps 2. Work problems on board	1. Assign problems and check

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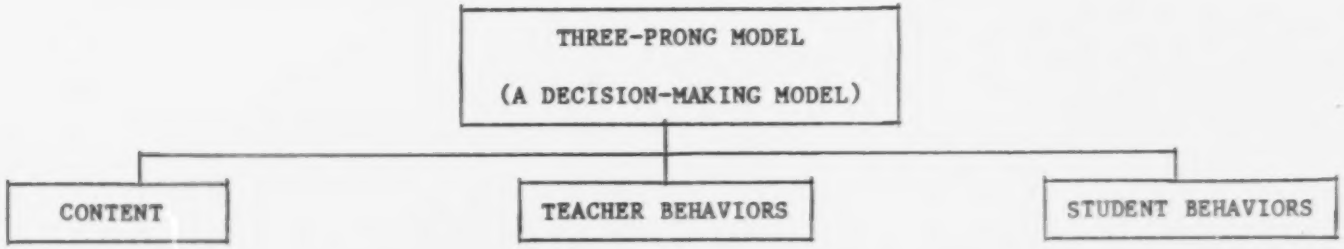
Adding out

1. Multiply either or both equations by a selected constant, such that when the two equations are added, one of the variables will cancel out.
2. Solve for the remaining variable.
3. Substitute result from step 2 into either equation and solve for remaining variable.

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the concept of "Matrix"

BY: Defining matrix and generating an example



VII.	Identify matrix (concept)	1. Define 2. Show example	1. Students will define 2. Students will generate an example

25

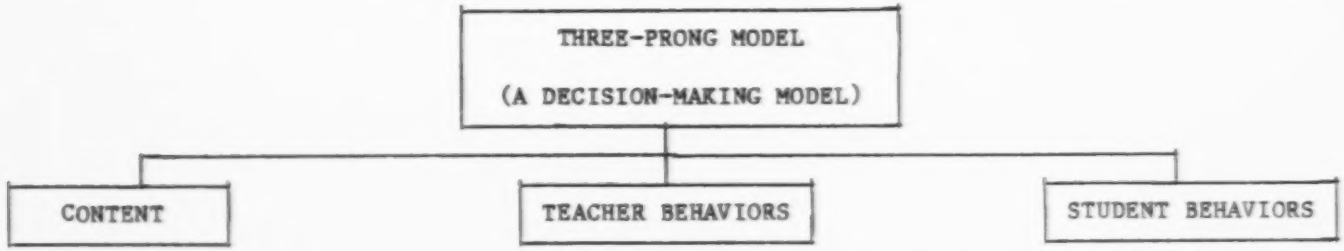
Example

Matrix

1. An ordered rectangular array of numbers, such that each element in the array can be referred to by row and column.

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the concept of matrix

BY: Defining matrix and giving a matrix



VIII. Identify matrix (concept)	1. Define 2. Show example	1. Students will define 2. Students will give example

26

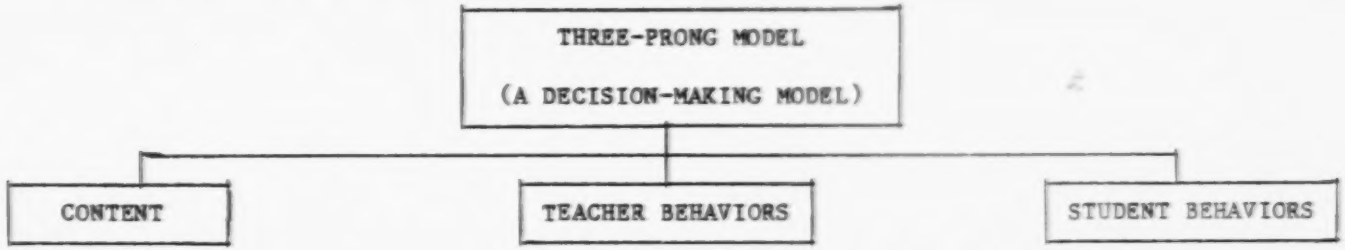
Example

Identify matrix .

1. A matrix I, such that AI = A

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the concept of "Inverse of a Matrix"

BY: Defining and generating an example



IX.	Inverse of A matrix (concept	1. Define 2. Show example	1. Students will define 2. Students will generate examples

Example

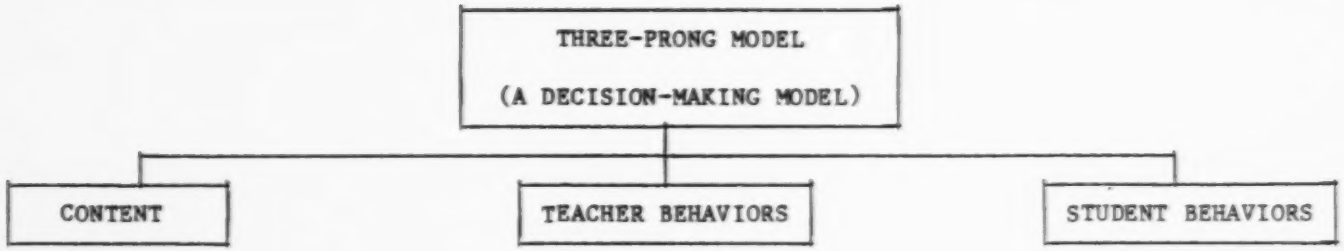
Inverse of a matrix

The inverse of a matrix A, called A^{-1}, such that $AA^{-1} = I$

27

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of addition and subtraction of a matrix

BY: Working and checking an assigned problem



	CONTENT	TEACHER BEHAVIORS	STUDENT BEHAVIORS
X.	Addition and subtraction of a matrix (process)	1. List steps 2. Demonstrate process on board	1. Assign problem to students and check

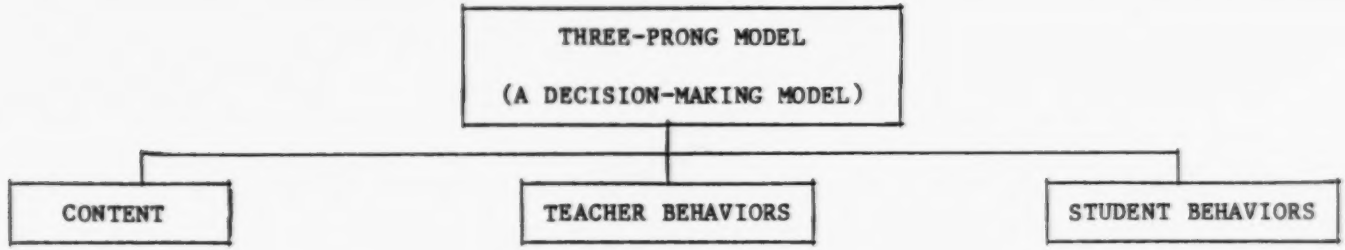
Example

Add and subtract of a matrix.

1. Add or subtract each corresponding element of the two matrixes to be added (or subtracted) to form a third matrix.

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of multiplication of two processes

BY: Working and checking an assigned problem



XI.	Multiplication of two matrixes (process)	1. List steps 2. Work problem on board	1. Assign problem to students and check.

Example

Multiplication of two matrixes (2 x 2 only)

$$\begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix} \quad \begin{bmatrix} B_1 & B_2 \\ B_3 & B_4 \end{bmatrix} = \begin{bmatrix} A_1B_1 \text{ \& } A_2B_3 & A_1B_2 \text{ \& } A_2B_4 \\ A_3B_1 \text{ \& } A_4B_3 & A_3B_2 \text{ \& } A_4B_4 \end{bmatrix} = \begin{bmatrix} C_1 & C_2 \\ C_3 & C_4 \end{bmatrix}$$

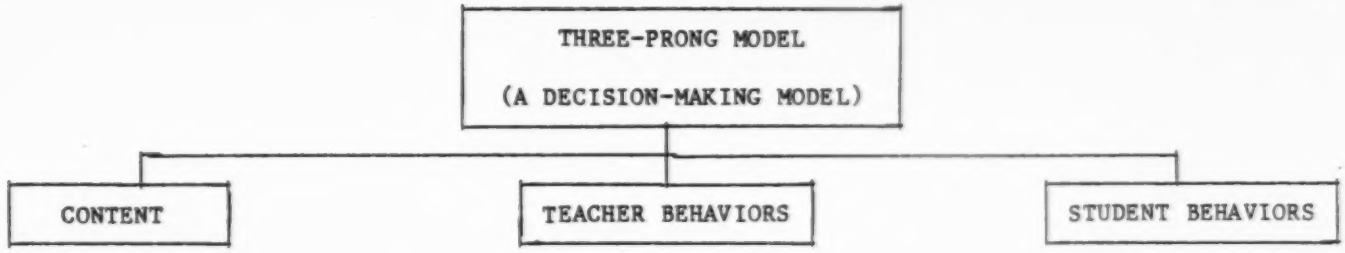
To multiply two matrixes A & B; such that AB = C:

1. $C_1 = A_1B_1 \text{ \& } A_2B_3$
2. $C_2 = A_1B_2 \text{ \& } A_2B_4$
3. $C_3 = A_3B_1 \text{ \& } A_4B_3$
4. $C_4 = A_3B_2 \text{ \& } A_4B_4$

29

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of the inverse of a matrix

BY: Working and checking an assigned problem



XII.	Calculation of the inverse of a matrix (process)	1. List steps 2. Show process on board	1. Give problem to students and check

Example

Calculation of inverse

1. Given matrix A, set up the problem as shown below:

$$\left[\begin{array}{cc|cc} A_1 & A_2 & 1 & 0 \\ A_3 & A_4 & 0 & 1 \end{array}\right] \longrightarrow \left[\begin{array}{cc|cc} 1 & 0 & ? & ? \\ 0 & 1 & ? & ? \end{array}\right]$$

2. Using rules a) and b) below, transform matrix A into the identity matrix.

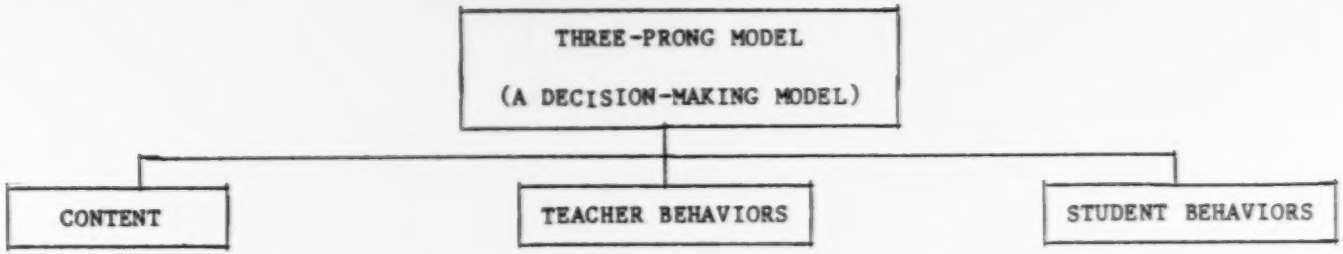
   a. Every element in any row may be multiplied by any number except zero.

   b. Rows may be added to other rows, element by element.

3. The new matirx, obtained on the right, is the inverse A^{-1} of A.

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of the solution of system using Grauss-Jordan Method

BY: Working and checking an assigned problem



CONTENT	TEACHER BEHAVIORS	STUDENT BEHAVIORS
XIII. Solution of system using Gauss-Jordan method (process)	1. List steps 2. Model on board	1. Give problem to students and check

Example

Solving a system of linear equations (Gauss-Jordan method)

1. Given a system such as: $A_1 X + A_2 Y = B$

$A_3 X + A_4 Y = C$

2. Set up a matrix equation as shown below:

$$\begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} B \\ C \end{bmatrix}$$

3. Calculate the inverse of $\begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix}$

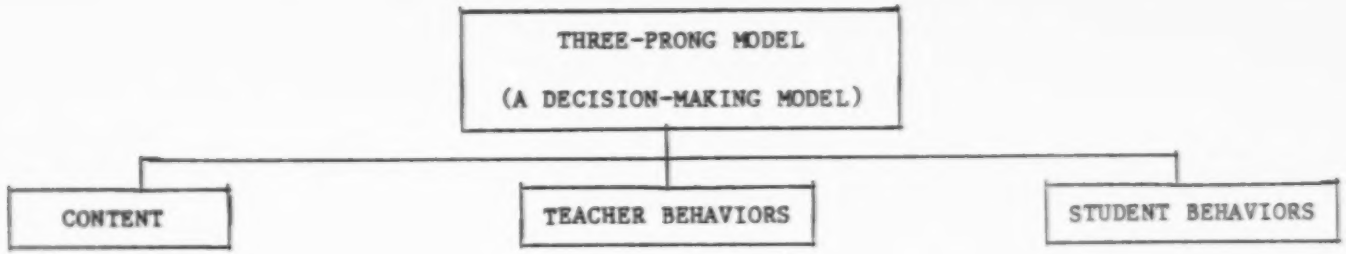
4. Multiply both sides of equation by A^{-1}

$$\begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix}^{-1} \begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix}^{-1} \begin{bmatrix} B \\ C \end{bmatrix}$$

Which reduces to: $\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} A_1 & A_2 \\ A3 & A4 \end{bmatrix}^{-1} \begin{bmatrix} B \\ C \end{bmatrix}$

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of the calculation of determinate

BY: Working and checking an assigned problem



CONTENT	TEACHER BEHAVIORS	STUDENT BEHAVIORS
XIV. Determinate - (calculation of process)	1. List steps 2. Model on board	1. Give problems to students and check

Example

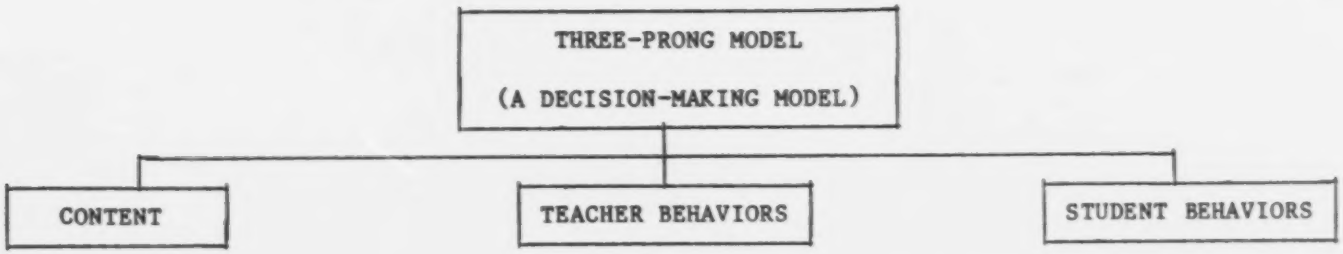
Calculation of a determinate

1. Given matrix $A = \begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix}$

2. Determinant $A = A_1A_4 - A_2A_3$

OBJECTIVE: LEARNER WILL: Demonstrate an understanding of the process of solution of equation using determinates

BY: Working and checking an assigned problem



CONTENT	TEACHER BEHAVIORS	STUDENT BEHAVIORS
XV. Solution of equation using determinates (process)	1. List steps 2. Model on board	1. Give problem to students and check.

Example

Solution of a system using determinates.

1. Given a system of equations: $A_1X + A_2Y = B$

$A_3X + A_4Y = C$

form a matrix equation:

$$\begin{bmatrix} A_1 & A_2 \\ A_3 & A_4 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} B \\ C \end{bmatrix}$$

RESOURCES

METRIC RELATIONSHIPS

FOR

ELECTRONICS RELATED MATH

METRIC RELATIONSHIPS

The base units in SI metrics include the metre and the gram. Other units of measure are related to these units. The relationship between the units is based on powers of ten and uses these prefixes:

kilo (1,000) hecto (100) deka (10) deci (0.1) centi (0.01) milli (0.001)

These tables show the most frequently used units with an asterisk (*).

METRIC LENGTH MEASURE

10 millimetres(mm)*	=	1 centimetre (cm)*
10 centimetres(cm)	=	1 decimetre(dm)
10 decimetres(dm)	=	1 metre (m)*
10 metres(m)	=	1 dekametre(dam)
10 dekametres(dam)	=	1 hectometre(hm)
10 hectometres(hm)	=	1 kilometre(km)*

- To express a metric length unit as a smaller metric length unit, multiply by a positive power of ten such as 10, 100, 1 000, 10 000, etc.
- To express a metric length unit as a larger metric length unit, multiply by a negative power of ten such as 0.1, 0.01, 0.001, 0.0001, etc.

METRIC AREA MEASURE

100 sq millimetres(mm^2)	=	1 sq centimetre(cm^2)*
100 sq centimetres(cm^2)	=	1 sq decimetre(dm^2)
100 sq decimetres (dm^2)	=	1 sq metre (m^2)*
100 sq metres(m^2)	=	1 sq dekametre(dam^2)
100 sq dekametres(dam^2)	=	1 sq hectometre(hm^2)
100 sq hectometres(hm^2)	=	1 sq kilometre(km2)

- To express a metric area unit as a smaller metric area unit, multiply by 100, 10 000, 1, 000 000, etc.
- To express a metric area unit as a larger metric area unit, multiply by 0.01, 0.000 1, 0.000 000 1, etc.

METRIC VOLUME MEASURE FOR SOLIDS

1 000 cu millimetres(mm^3)	=	1 cu centimetre(cm^3)
1 000 cu centimetres(cm^3)	=	1 cu decimetre(dm^3)
1 000 cu decimetres(dm^3)	=	1 cu metre (m^3)
1 000 cu metres (m^3)	=	1 cu dekametre(dam^3)
1 000 cu dekametres(dam^3)	=	1 cu hectometre(hm^3)
1 000 cu hectometre(hm^3)	=	1 cu kilometre(km^3)

- To express a metric volume unit for solids as a smaller metric volume unit for solids, multiply by 1 000, 1 000 000, 1 000 000 000, etc.
- To express a metric volume unit for solids as a larger metric volume unit for solids as a larger metric volume unit for solids, multiply by 0.001, 0.000 001, 0.000 000 001, etc.

METRIC VOLUME MEASURE FOR FLUIDS

10 millilitres(mL)*	=	1 centilitre (cL)
10 centilitres (cL)	=	1 decilitre (dL)
10 decilitres (dL)	=	1 litre (L)*
10 litres (L)	=	1 dekalitre (daL)
10 dekalitres (daL)	=	1 hectolitre (hL)
10 hectolitre (hL)	=	1 kilolitre (kL)

- To express a metric volume unit for fluids as a smaller metric volume unit for fluids, multiply by 10, 100, 1 000, 10 000, etc.
- To express a metric volume unit for fluids as a larger metric volume unit for fluids, multiply by 0.1, 0.01, 0.001, 0.000 1, etc.

METRIC VOLUME MEASURE EQUIVALENTS
1 cubic decimetre(dm^3) = 1 litre (L)
1 000 cubic centimetres(cm^3) = 1 litre (L)
1 cubic centimetre(cm^3) = 1 millilitre (mL)

METRIC MASS MEASURE		
10 milligrams (mg)*	=	1 centigram (cg)
10 centigrams (cg)	=	1 decigram (dg)
10 decigrams (dg)	=	1 gram (g)*
10 grams (g)	=	1 dekagram (dag)
10 dekagrams (dag)	=	1 hectogram (hg)
10 hectograms (hg)	=	1 kilogram (kg)*
10 kilograms (kg)	=	1 megagram (Mg)*

- To express a metric mass unit as a smaller metric mass unit, multiply by 10, 100, 1 000, 10 000, etc.
- To express a metric mass unit as a larger metric mass unit, multiply by 0.1, 0.01, 0.001, 0.000 1, etc.

Metric measurements are expressed in decimal parts of a whole number. For example, one-half millimetre is written as 0.5 mm.

In calculating with the metric system, all measurements are expressed using the same prefixes. If answeres are needed in millimetres, all parts of the problem should be expressed in millimetres before the final solution is attempted. Diagrams that have dimensions in different prefixes must first be expressed using the same unit.

UNITS AND TABLES OF ELECTRONIC MEASUREMENT

The field of electronics is made up of many complex units and numbers. In order to communicate correctly it is important that each person in the field use the same language. A set of standard units and symbols is used. Table I lists the units and symbols most commonly used in electronics. These are used extensively in electronics.

TABLE I QUANTITIES AND UNITS OF MEASUREMENT

QUANTITY	UNIT	EXAMPLE
Capacitance (C)	fard(F)	C_1 = 0.000 01 F
Capacitive reactance (X_c)	ohm ( )	X_c = 45
Current (I)	ampere (A)	I_1 = 0.5 A
frequency (f)	hertz (Hz)	f = 60 Hz
Impedance (Z)	ohm ( )	Z = 50
Inductance (L)	henry (H)	L_2 = 0.15 H
Inductive reactance (X_L)	ohm ( )	X_L = 37
Power (P)	watt (W)	P = 100 W
Reactance (X)	ohm ( )	X = 12
Resistance (R)	ohm ( )	R_2 = 15
Time (t)	second (s)	t = 0.8s
Voltage (E or V)	volt (V)	E_s = 12 V

There is a need to make numbers like 68 000 000 ohms or 0.000 052 amperes easier to write. To simplify standard units only specific powers of ten are used. The powers used most are 10^6, 10^3, 10^{-3}, 10^{-6}, and 10^{-12}.

MEGA: When mega is used as a prefix it stands for one million or 10^6. For example, 5 megavolts means 5 x 10^6 volts or 5 000 000 volts. The value 15 megohms means 15 x 10^6 ohms or 15 000 000 ohms. The letter that indicates mega is M. Therefore 5 megavolts is written 5 MV and 15 megohms is written 15 M .

KILO: When kilo is used as a prefix it stands for 10^3 or 1 000. For example, 5.6 kilohms means 5.6 x 10^3 ohms or 5 600 ohms. The value 0.85 kilohertz means 0.85 x 10^3 hertz or 850 hertz. The letter used to indicate kilo is k. Therefore 5.6 kilohms is 5.6k and 0.85 kilohertz is 0.85 kHz.

MILLI: When milli is used as a prefix it stands for 0.001 or 10^{-3}. For example, 26 milliameperes means 26 x 10^{-3} amperes or 0.026 amperes. The value 8 milliwatts means 8 x 10^{-3} watts or 0.008 watts. The letter that indicates milli is m. Therefore 26 millamperes is 26 mA and 8 milliwatts is 8mW.

MICRO: When micro is used as a prefix it stands for 10^{-6}, 0.000 001, or one millionth. For example, 75 microhenries means 75 x 10^{-6} henries or 0.000 075 henries. The value 359 microseconds means 359 x 10^{-6} seconds or 0.000 359 second. The letter that indicates micro is u . This is the grek letter mu. Therefore 75 microhenries is 75 uH and 359 microseconds is 359 us .

PICO: When pico is used as a prefix it stands for 10^{-12}. For example, 150 picofarad means 150 x 10^{-12} farad or 0.000 000 000 15 farad. The letter that indicates pico is p. Therefore 150 picfarads is 150 pF.

TABLE II POWERS OF TEN

NUMBER	POWER	PREVIX	LETTER
1 000 000 000 000	10^{12}	terra	T
1 000 000 000	10^{9}	giga	G
1 000 000	10^{6}	mega	M
1 000	10^{3}	kilo	k
1	10^{0}		
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	u
0.000 000 001	10^{-9}	nano	n
0.000 000 000 001	10^{-12}	pico	p

There are many times when units of measurement must be added, subtracted, multiplied and divided. Operations such as these will become easier with practice.

ADDITION AND SUBTRACTION: When units are added or subtracted they must be in the same units. To add 470 ohms and 1.2 kilohms one value or the other must be expressed as the other unit. THis would mean 470 ohms plus 1 200 ohms or 0.47 kilohm plus 1.2 kilohms. The answer of course would be 1 670 ohms or 1.67 kilohms.

MULTIPLICATION AND DIVISION: There are many situations in which electronic units will be multiplied and/or divided. Tables III AND IV have been provided as guides in working Ohm's Law and Power Law problems. While these tables will not contain all possible combinations they will assist the student in working basic problems. The student will want to refer to an electronics text for additonal information on combination Ohm's Law and Power Law problems.

ACCEPTABLE UNITS: There are many units a given answer or value could be expressed in. Assume you have a voltage of 0.25 volt. This could also be written as 250 millivolts, 250 000 microvolts, or 0.000 25 kilovolt. As a general rule, if there are more than three numbers preceding or following a decimal point then a change of units should be made. In the above example the voltage of 0.25 volt and 250 millivolts would be the most acceptable. Look at these other examples:

4 700 V = 4.7 kV
0.182 6 A = 182.6 mA
1 600 000 = 1.6 M

TABLE III OHMS'S LAW UNITS

OPERATION	SYMBOL	RESULTANT
amperes X ohms	A X	volt (V)
ampers X kilohms	A X k	kilovolts (kV)
ampers X megohms	A X M	megavolts (MV)
milliamperes X ohms	mA X	millivolts (mV)
milliamperes X kilohms	mA X k	volts (V)
milliamperes X megohms	ma X M	kilovolts (kV)
microamperes X ohms	uA X	microvolts (V)
microamperes X kilohms	uA X k	millivolts (mV)
microamperes X megohms	uA X M	volts (V)
volts ÷ ohms	V ÷	amperes (A)
volts ÷ kilohms	V ÷ k	milliamperes (mA)
volts ÷ megohms	V ÷ M	microamperes (uA)
millivolts ÷ ohms	mV ÷	milliamperes (mA)
millivolts ÷ kilohms	mV ÷ k	microamperes (uA)
millivolts ÷ megohms	mV ÷ M	nanoamperes (nA)
volts ÷ amperes	V ÷ A	ohms ( )
volts ÷ milliamperes	V ÷ mA	kilohms (k)
volts ÷ microamperes	V ÷ uA	megohms (M)
millivolts ÷ amperes	mV ÷ A	milliohms (m)
millivolts ÷ milliamperes	mV ÷ mA	ohms ( )
millivolts ÷ microamperes	mV ÷ uA	kilohms (k)

TABLE IV POWER LAW UNITS		
OPERATION	SYMBOL	RESULTANT
amperes X volts	A X V	watts (W)
amperes X millivolts	A X mV	milliwatts (mW)
amperes X microvolts	A X uV	microwatts (uW)
milliamperes X volts	mA X V	milliwatts (mW)
milliamperes X millivolts	mA X mV	microwatts (uW)
milliamperes X microvolts	mA X uV	nanowatts (nW)
watts ÷ volts	W ÷ V	amperes (A)
watts ÷ kilovolts	W ÷ kV	milliamperes (mA)
watts ÷ megavolts	W ÷ MV	microamperes (uA)
milliwatts ÷ volts	mW ÷ V	milliamperes (mA)
milliwatts ÷ millivolts	mW ÷ mV	amperes (A)
watts ÷ amperes	W ÷ A	volts (V)
watts ÷ milliamperes	W ÷ mA	kilovolts (kV)
watts ÷ microamperes	W ÷ uA	megavolts (MV)
milliwatts ÷ amperes	mW ÷ A	millivolts (mV)
milliwatts ÷ milliamperes	mW ÷ mA	volts (V)
milliwatts ÷ microamperes	mW ÷ uA	kilovolts (kV)

TABLE V COMBINATION OHM'S LAW AND POWER LAW EQUATIONS		
EQUATION	OPERATION	RESULTANT
$E = P \times R$	voltage = watts X ohms	volts (V)
$E = \frac{P}{I}$	voltage = $\frac{\text{watts}}{\text{amperes}}$	volts (V)
$E = I \times R$	voltage = amperes X ohms	volts (V)
$I = \frac{E}{R}$	current = $\frac{\text{volts}}{\text{ohms}}$	amperes (A)
$I = \frac{P}{E}$	current = $\frac{\text{watts}}{\text{volts}}$	amperes (A)
$I = \frac{P}{R}$	current = $\frac{\text{watts}}{\text{ohms}}$	amperes (A)
$P = I \times E$	power = amperes X volts	watts (W)
$P = I^2 \times R$	power = amperes^2 X ohms	watts (W)
$P = \frac{E^2}{R}$	power = $\frac{\text{volts}^2}{\text{ohms}}$	watts (W)
$R = \frac{E}{I}$	resistance = $\frac{\text{volts}}{\text{amperes}}$	ohms ( )
$R = \frac{E^2}{P}$	resistance = $\frac{\text{volts}^2}{\text{watts}}$	ohms ( )
$R = \frac{P}{I^2}$	resistance = $\frac{\text{watts}}{\text{amperes}^2}$	ohms ( )

Carbon and composition resistors are usually marked with colored bands. Each band stands for a specific digit, the number of zeros, or the resistor tolerance. The tolerance is the percent the resistor value varies from its indicated value.

TABLE VI RESISTOR COLOR CODE				
	1st Band	2nd Band	3rd Band	4th Band
COLOR	1st Digit	2nd Digit	Number of Zeros	Tolerance
Black	-	0	0	-
Brown	1	1	1	-
Red	2	2	2	-
Orange	3	3	3	-
Yellow	4	4	4	-
Green	5	5	5	-
Blue	6	6	6	-
Violet	7	7	7	-
Gray	8	8	8	-
White	9	9	9	-
Gold	-	-	x.1	5%
Silver	-	-	x.01	10%
None	-	-	-	20%

[1]

[1]Richard L. Sullivan, Practical Problems in Mathematic for Electronics Technicians, Delmar Publishers Inc., Albany, New York, 1982, pp. 190 - 193, pp. 198 - 199, pp. 202 - 203

RESOURCES

ELECTRONIC TECHNICIAN SURVEY

The Electronics Technician survey instrument may be used in any of the following ways:

1) Pre-test, Post-test

2) Scope and sequence review of skills prior to entering an electronics technician course

3) Individualized study packet for self-learning, self-check

The Electronics Technician Survey was developed by Deanna Geffe, Carol Bement - Learning Resource Center Instructors and Chuck Ayling and Tom Macy - Electronics Technician Instructors at Lake Washington Vocational Technical Institute.

ELECTRONIC
TECHNICIAN
SURVEY

DO NOT WRITE IN THIS PACKET

ELECTRONICS
MATH AND READING SURVEY

1. An annual inventory requires that all of the resistors in stock be counted. During five days 3 825, 1 627, 2 874, 4 926, and 3 041 resistors are counted. Find the total number in stock.

2. A television repair technician receives checks for $126.58, $37.95, $95.73, and $258.08 for making repairs. The technician spends $328.00 for spare parts. Find the amount of money remaining.

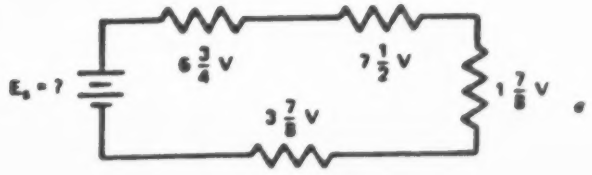
3. A delivery van travels at 82 kilometres per hour for 3.5 hours. The van averages 14 kilometres per gallon of gas. How many gallons of gas are used?

4. The resistor (R) in this diagram draws a current (I) of 2 A. Find the voltage drop (E), in volts, across it.

   Note: E = I X R

5. A shipment of 4 550 diodes are separated into 14 boxes. How many diodes are in each box?

6. The sum of the voltage drops in a series circuit equals the source voltage (E_s). Use this circuit to find E_s.



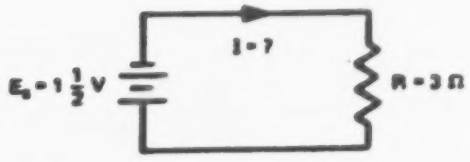
7. A piece of cable is 27 3/16 inches long. How many inches remain after 11 27/32 inches are cut off?

8. During the installation of a closed circuit television system 3 workers spend 9 1/2 hours per day for the first 2 days. On the third day another member joins the crew. The group works 9 1/2 hours per day for 2 more days. Find the total hours worked.

9. The current gain of an amplifier is found by dividing the output current by the input current. The input current is 3/8 mA and the output current is 15 3/4 mA. Find the current gain.

10. Use this circuit to find the indicated values.

Note: $I = E \div R$
$P = I \times E$



a. Find the current (I) in amperes.

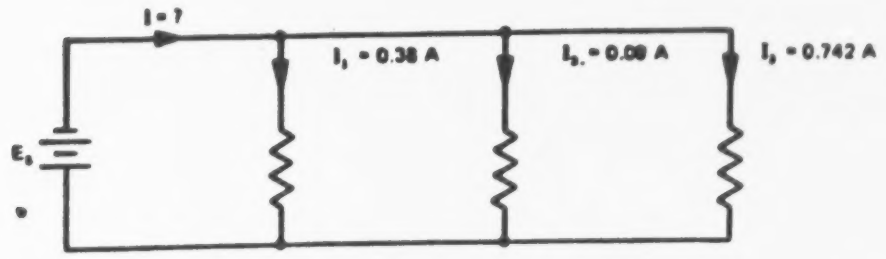
b. Find the power (P) in watts.

11. Express 9/16 as a decimal.

12. Express 0.625 as a fraction in lowest terms.

13. The branch currents in a parallel circuit are added to form total current (I_t). Use this circuit to find I_t.

Note: $I_t = I_1 + I_2 + I_3$



14. A technician has a roll of wire that is 500 m long. Pieces of 37.8 m, 65.14 m, 11 m, and 41.08 m long are cut off. How much wire is left?

15. Find the rms voltage (E_{rms}) of an AC signal with a 25-V peak (E_p).

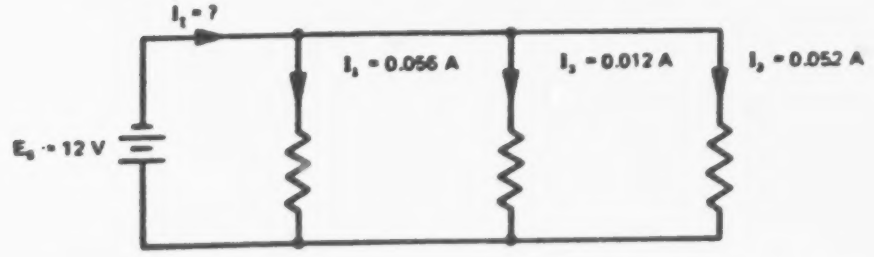
Note: $E_{rms} = 0.707 \times E_p$

16. Find the frequency (f), of a signal, in hertz, with a period (t) of 0.000 8 s.

Note: $f = 1/t$

17. Find the total circuit resistance (R_t) in this circuit.

Note: $I_t = I_1 + I_2 + I_3$ and $R_t = E_s \div I_t$



18. What is the value of 7^2?

19. What is the value of 4^4?

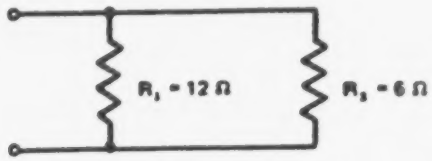
20. What is the value of $(3/4)^2$?

21. Find the square root of 625.

22. What is the value of $\sqrt{9/16}$?

23. Use this formula and circuit to find total resistance (R_t).

Note: $R_t = \frac{R_1 \times R_2}{R_1 + R_2}$



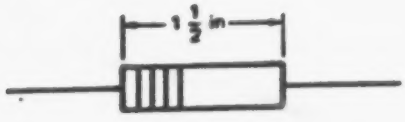
24. Express the ratio 12:18 in lowest terms.

25. Find the ratio of 2.2 kΩ to 11 000 Ω.

26. Calculate the missing quantity in the proportion 5:2 = x:100.

27. Find the length, in centimetres, of the resistor in this diagram.

Note: 1 in = 2.54 cm



28. The base of a tube is circular and is 0.75 inches in diameter (d). Find the circumference (C).

Note: $C = \pi d$, where $\pi = 3.14$

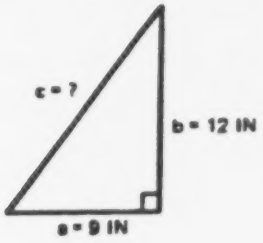
29. Find 82.5% of 158.

30. During a test 37 out of 41 turntables checked acceptable. What percent are acceptable? Express the answer to the nearer hundredth percent.

31. Find the average of 42 mA, 38.2 mA, 15.8 mA, 50.5 mA, and 48 mA.

32. Find the length of the missing side in this right triangle.

Note: $c = \sqrt{a^2 + b^2}$

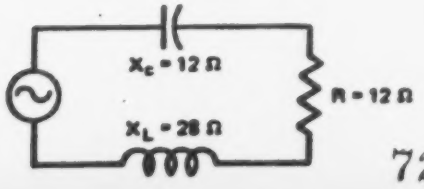


33. Calculate side b in this diagram.

Note: $b = \sqrt{c^2 - a^2}$

34. Calculate impedance (Z), in ohms, for this series RCL circuit.

Note: $Z = \sqrt{R^2 + (X_L - X_C)^2}$



COMPREHENSION

Sample: Read the passage below.

Joe decided to get a part-time job after school. He looked in the classified section of the newspaper since this part contains the help wanted notices. He found two companies near home which were hiring and called for an appointment for an interview.

Now read the item below.

The classified section of the newspaper contains

a. secret information
b. help wanted notices
c. current news stories
d. advice to the lovelorn

Look at the section of your answer sheet under the word Comprehension. Put a "b" on the line for the answer for the sample item because the classified section of the newspaper contains "help wanted notices."

Items 1-3 measure your knowledge of reference information.
Read each question and mark your answer on the answer sheet.

1. A glossary contains
   a. definitions
   b. quotes from famous people
   c. tables and diagrams
   d. an overview of the book
2. The appendix of a book consists of
   a. unusual words used in the text
   b. a list of chapter headings
   c. a list of authors
   d. supplementary material
3. A bibliography contains
   a. a list of important names and dates
   b. a list of books
   c. a list of topics covered in the text
   d. a list of words used in the text

Now read the Table of Contents on the next page. Answer the questions which follow.

TABLE OF CONTENTS

CHAPTER		PAGE
1.	Electricity—The Behavior of Electrons	1
2.	Electrical Circuits	22
3.	Electrical Energy & Power	41
4.	Electric Heating & Lighting	86
5.	Cells & Batteries	129
6.	Motors	154
7.	Amplifiers	221
8.	Safety in Electricity-Electronics Shops	235
9.	Careers in Electricity & Electronics	253

4. The chapter "Electric Heating & Lighting" begins on page
   a. 41 b. 68 c. 86 d. 129

5. Page 145 is in which chapter?
   a. "Motors"
   b. "Cells & Batteries"
   c. "Electrical Energy & Power"
   d. "Amplifiers"

6. Information on an occupation in electrical engineering can be found in which chapter?
   a. 1 b. 5 c. 7 d. 9

Read the Index. Then do items 7-9 and mark your answers on

INDEX

Charges, electric, defined, 3
  laws of, 4
Circuit breakers, defined, 126-127
Clamps, cable, 147
  in boxes, 161
  ground, 203
Codes, local, 92
Conductors, defined, 5
  insulation, 97-98
  joints, 111
  sizes, 93-95
  skin effects on, 95-96
  soldering, 110-111

7. The meaning of the word "conductor" is on page
   a. 3
   b. 4
   c. 5
   d. 111

8. The local electrical codes can be found on page
   a. 203
   b. 92
   c. 93
   d. 147

9. The effects of conductors on the skin begins on page
   a. 161
   b. 5
   c. 93
   d. 95

Read the passages. After each passage, choose the best answer for each item and mark your answer on the answer sheet.

For a rough classification, magnets may be divided into two groups: permanent or temporary. A permanent magnet is intended to keep its atomic arrangement steady after the magnetizing force is removed. Permanent magnets are used in telephone receivers, door latches, small d.c. motors, electrical measuring instruments, magnetos, speedometers, and a great variety of gadgets. For years, high-carbon tool steel, and a few alloy steels (cobalt, molybdenum, chrome-tungsten) were the only useful permanent magnet materials. Later, various alloys were developed, such as Alnico (aluminum, nickel, cobalt, iron), which is widely used as a high-strength permanent magnet. Flexible rubbery magnets are made by mixing magnetic oxide powders with vinyl and other plastics.

Temporary-magnet materials, which are easily and strongly magnetized but lose most of their strength when the magnetizing force is removed, are of more importance than permanent-magnet materials, both in total amount in use and in variety of applications. The first-used material for temporary magnets was plain iron, as pure as could be obtained, softened by annealing (slow cooling). A soft metal is one in which atoms slide around readily, permitting atoms to be magnetically disarranged easily. The most-used material is silicon iron (2-4% Si), a soft alloy used in transformers, most motors and generators, relays and other magnetic equipment built in large quantities.

Answer questions 10-13.

10. The best title for this selection is
    a. "Temporary Magnets"
    b. "Permanent Magnets"
    c. "Types of Magnetic Materials"
    d. "Electromagnetic Force"

11. As used in this passage, the term "annealing" means
    a. fast cooling
    b. slow cooling
    c. easily magnetized
    d. softening

12. Which of the following is not a permanent magnet material?
    a. silicon
    b. high-carbon tool steel
    c. alloy steel
    d. Alnico

13. Temporary magnets are used in
    a. telephone receivers
    b. door latches
    c. speedometers
    d. transformers

Read the passage on the following page and answer questions 14-16.

To use an ohmmeter, the tips of the test leads are first held together (short-circuited) and the rheostat adjusted so that the pointer of the meter moves over to the righthand end of the scale, where the "zero ohms" mark is placed. The meter now indicates that there is zero resistance between the test leads.

When the test leads are separated, there is no current in the circuit, and the pointer drops back to the left end of the scale, where the "infinity ohms" mark is placed.

When the test leads are touched to the ends of a resistor of unknown value, the resistance is read directly from the "ohms" scale. Normally, an ohmmeter has several ranges, with different combinations of series resistance and battery voltage used in each range.

The ohmmeter diagrammed in Fig. 7-10 is called a series ohmmeter, and is usually installed in a case containing multiple-contact switches, voltmeter resistors, and ammeter shunts, forming the "multimeter" or "volt-ohmmeter" that is widely used in testing electronic equipment.

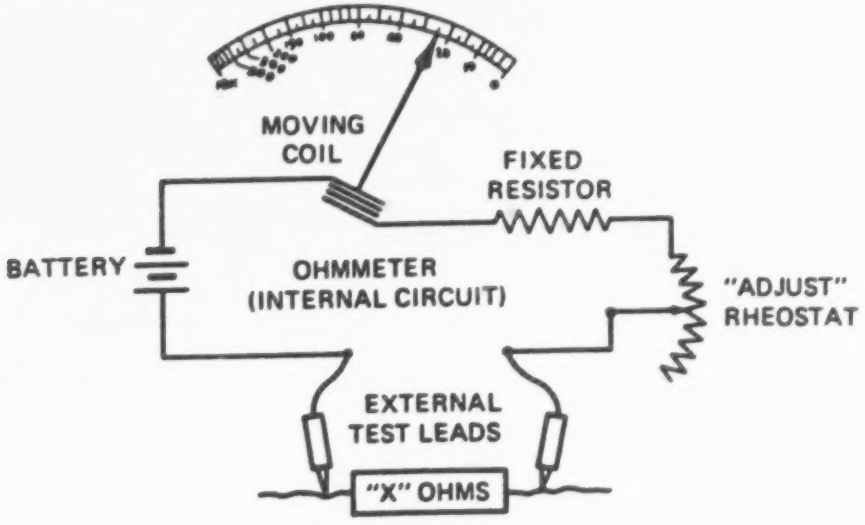


Fig. 7-10 Ohmmeter Circuit

14. To use an ohmmeter, the rheostat must first be set at
    a. zero b. infinity c. 10 ohms d. 10 K ohms
15. The following steps are used to measure resistance in a circuit. Which step is taken first?
    a. connect ohmmeter
    b. discharge electrolytic capacitors
    c. turn off power
    d. read "ohm" scale
16. When there is no current in a circuit, what is the reading on the ohmmeter scale?
    a. zero b. infinity c. 10 ohms d. 100 ohms

Read the passage on the following page and answer questions 17-20. Put your answers on the answer sheet.

Light is energy that is radiated by electronic disturbances in atoms. Electrons in an atom can accumulate energy in many ways: from heat, as in a red-hot object; or by being hit by other electrons, as in a gas-conduction tube; or by absorbing energy radiated by other materials. Sooner or later, this absorbed energy is given out. The amount of energy that an electron can get rid of in one burst depends on where the electron is, that is, what kind of atom it is in, and its location in the atom.

The energy is radiated as a wave-like pulse of electric lines of force and magnetic lines of force, which is called an electromagnetic wave. The vibration frequency of these traveling lines of force is proportional to the amount of energy that the electron gave off. Frequencies in the range from 4.3×10^{14} to 7.5×10^{14} vibrations per second affect electrons in our eyes. We call electromagnetic waves in this frequency range by the name of "light."

Waves of a frequency slightly higher than 7.5×10^{14} are called "ultra-violet," waves in a lower frequency range, from 10^{11} to 10^{14} vibrations per second are called "infra-red," and heat radiation. The term "black light," often used by newspaper reporters who do not know the correct terms, may mean either ultra-violet or infra-red. Ultra-violet and infra-red differ greatly in their effects and uses.

17. The best title for this passage is
    a. "How Light Is Measured"
    b. "What Is Light?"
    c. "Sources of Light"
    d. "Commercial Light Sources"

18. Which of the following is not one of the ways electrons in an atom accumulate energy?
    a. by being hit by other electrons
    b. by absorbing energy radiated by other materials
    c. from cooling temperatures
    d. from heat

19. Define "light"

20. Define "light" a second way

On the following page you will find a diagram. Use the diagram to answer questions 21-23. Mark your answers on the answer sheet.

NATURAL SINES AND COSINES

NOTE For cosines, use right-hand columns of degrees and lower line of tenths

Deg	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
45	0.7071	0.7083	0.7096	0.7108	0.7120	0.7133	0.7145	0.7157	0.7169	0.7181	0.7193	44
46	0.7193	0.7206	0.7218	0.7230	0.7242	0.7254	0.7266	0.7278	0.7290	0.7302	0.7314	43
47	0.7314	0.7325	0.7337	0.7349	0.7361	0.7373	0.7385	0.7396	0.7408	0.7420	0.7431	42
48	0.7431	0.7443	0.7455	0.7466	0.7478	0.7490	0.7501	0.7513	0.7524	0.7536	0.7547	41
49	0.7547	0.7560	0.7570	0.7581	0.7593	0.7604	0.7615	0.7627	0.7638	0.7649	0.7660	40
50°	0.7660	0.7672	0.7683	0.7694	0.7705	0.7716	0.7727	0.7738	0.7749	0.7760	0.7771	39
51	0.7771	0.7782	0.7793	0.7804	0.7815	0.7826	0.7837	0.7848	0.7859	0.7869	0.7880	38
52	0.7880	0.7891	0.7902	0.7912	0.7923	0.7934	0.7944	0.7955	0.7965	0.7976	0.7986	37
53	0.7986	0.7997	0.8007	0.8018	0.8028	0.8039	0.8049	0.8059	0.8070	0.8080	0.8090	36
54	0.8090	0.8100	0.8111	0.8121	0.8131	0.8141	0.8151	0.8161	0.8171	0.8181	0.8192	35
55	0.8192	0.8202	0.8211	0.8221	0.8231	0.8241	0.8251	0.8261	0.8271	0.8281	0.8290	34
56	0.8290	0.8300	0.8310	0.8320	0.8329	0.8339	0.8348	0.8358	0.8368	0.8377	0.8387	33
57	0.8387	0.8396	0.8406	0.8415	0.8425	0.8434	0.8443	0.8453	0.8462	0.8471	0.8480	32
58	0.8480	0.8490	0.8499	0.8508	0.8517	0.8526	0.8536	0.8545	0.8554	0.8563	0.8572	31
59	0.8572	0.8581	0.8590	0.8599	0.8607	0.8616	0.8625	0.8634	0.8643	0.8652	0.8660	30
60°	0.8660	0.8669	0.8678	0.8686	0.8695	0.8704	0.8712	0.8721	0.8729	0.8738	0.8746	29
61	0.8746	0.8755	0.8763	0.8771	0.8780	0.8788	0.8796	0.8805	0.8813	0.8821	0.8829	28
62	0.8829	0.8838	0.8846	0.8854	0.8862	0.8870	0.8878	0.8886	0.8894	0.8902	0.8910	27
63	0.8910	0.8918	0.8926	0.8934	0.8942	0.8949	0.8957	0.8965	0.8973	0.8980	0.8988	26
64	0.8988	0.8996	0.9003	0.9011	0.9018	0.9026	0.9033	0.9041	0.9048	0.9056	0.9063	25
65	0.9063	0.9070	0.9078	0.9085	0.9092	0.9100	0.9107	0.9114	0.9121	0.9128	0.9135	24
66	0.9135	0.9143	0.9150	0.9157	0.9164	0.9171	0.9178	0.9184	0.9191	0.9198	0.9205	23
67	0.9205	0.9212	0.9219	0.9225	0.9232	0.9239	0.9245	0.9252	0.9258	0.9265	0.9272	22
68	0.9272	0.9278	0.9285	0.9291	0.9298	0.9304	0.9311	0.9317	0.9323	0.9330	0.9336	21
69	0.9336	0.9342	0.9348	0.9354	0.9361	0.9367	0.9373	0.9379	0.9385	0.9391	0.9397	20°
70°	0.9397	0.9403	0.9409	0.9415	0.9421	0.9426	0.9432	0.9438	0.9444	0.9449	0.9455	19
71	0.9455	0.9461	0.9466	0.9472	0.9478	0.9483	0.9489	0.9494	0.9500	0.9505	0.9511	18
72	0.9511	0.9516	0.9521	0.9527	0.9532	0.9537	0.9542	0.9548	0.9553	0.9558	0.9563	17
73	0.9563	0.9568	0.9573	0.9578	0.9583	0.9588	0.9593	0.9598	0.9603	0.9608	0.9613	16
74	0.9613	0.9617	0.9622	0.9627	0.9632	0.9636	0.9641	0.9646	0.9650	0.9655	0.9659	15
75	0.9659	0.9664	0.9668	0.9673	0.9677	0.9681	0.9686	0.9690	0.9694	0.9699	0.9703	14
76	0.9703	0.9707	0.9711	0.9715	0.9720	0.9724	0.9728	0.9732	0.9736	0.9740	0.9744	13
77	0.9744	0.9748	0.9751	0.9755	0.9759	0.9763	0.9767	0.9770	0.9774	0.9778	0.9781	12
78	0.9781	0.9785	0.9789	0.9792	0.9796	0.9799	0.9803	0.9806	0.9810	0.9813	0.9816	11
79	0.9816	0.9820	0.9823	0.9826	0.9829	0.9833	0.9836	0.9839	0.9842	0.9845	0.9848	10°
80°	0.9848	0.9851	0.9854	0.9857	0.9860	0.9863	0.9866	0.9869	0.9871	0.9874	0.9877	9
81	0.9877	0.9880	0.9882	0.9885	0.9888	0.9890	0.9893	0.9895	0.9898	0.9900	0.9903	8
82	0.9903	0.9905	0.9907	0.9910	0.9912	0.9914	0.9917	0.9919	0.9921	0.9923	0.9925	7
83	0.9925	0.9928	0.9930	0.9932	0.9934	0.9936	0.9938	0.9940	0.9942	0.9943	0.9945	6
84	0.9945	0.9947	0.9949	0.9951	0.9952	0.9954	0.9956	0.9957	0.9959	0.9960	0.9962	5
85	0.9962	0.9963	0.9965	0.9966	0.9968	0.9969	0.9971	0.9972	0.9973	0.9974	0.9976	4
86	0.9976	0.9977	0.9978	0.9979	0.9980	0.9981	0.9982	0.9983	0.9984	0.9985	0.9986	3
87	0.9986	0.9987	0.9988	0.9989	0.9990	0.9990	0.9991	0.9992	0.9993	0.9993	0.9994	2
88	0.9994	0.9995	0.9996	0.9996	0.9996	0.9997	0.9997	0.9997	0.9998	0.9998	0.9998	1
89	0.9998	0.9999	0.9999	0.9999	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0°
	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0	Deg

24. What is the natural sine of a 57.3° angle?

a. 0.8508
c. 0.8415
b. 0.8453
d. 0.8320

25. What is the natural cosine of a 28.4° angle?

a. 0.8780
c. 0.8878
b. 0.8796
d. 0.8805

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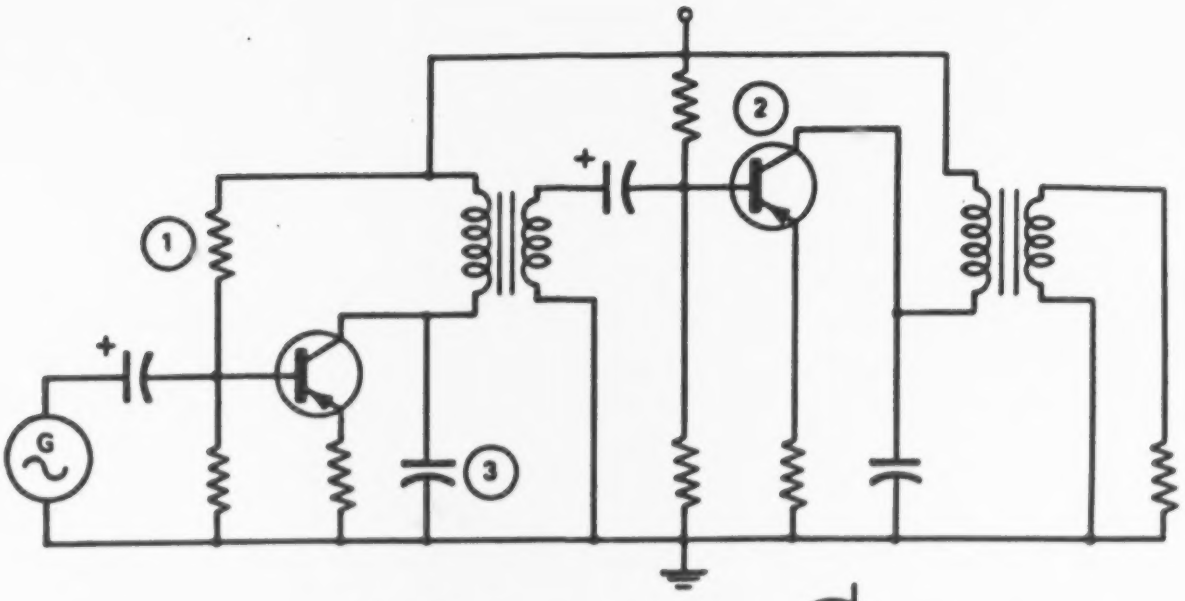
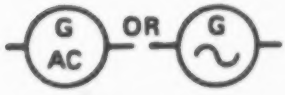


RESISTOR

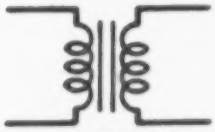
BATTERY (6.0 VOLT)

TRANSISTOR, NPN

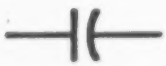
DIODE



GENERATOR (AC)



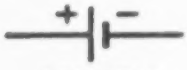
TRANSFORMER



CAPACITOR

THERMOCOUPLE

TRANSISTOR, PNP



DRY CELL
(1.5 VOLT)

21. Find 1 on the diagram. This symbol refers to a
    a. capacitor
    b. resistor
    c. transformer
    d. battery

22. Find 2 on the diagram. This symbol refers to a
    a. diode
    b. transistor, NPN
    c. transistor, PNP
    d. thermocouple

23. Find 3 on the diagram. This symbol refers to a
    a. battery
    b. generator
    c. dry cell
    d. capacitor

Use the Table of Natural Sines and Cosines to answer questions 24-25.

DIRECTIONS:

WORK THE PROBLEMS IN THE SPACE PROVIDED. CIRCLE YOUR ANSWER WHEN YOU ARE FINISHED.

1. 16 293 resistors

2. ~~#109.34~~ 190.34

3. $82\ Km/h \times 3.5 = 287\ Km$

$\frac{287\ Km}{14\ Km/gal} = 20.5\ gal.$

4. $E = 2A \times 15\Omega = 30V$

5. $\frac{4550}{14} = 325$

6. $E_s = 6\frac{3}{4}V + 7\frac{1}{2}V + 1\frac{7}{8}V + 3\frac{7}{8}V =$

$E_s = 20V$

7. $27\frac{3}{16}" - 11\frac{27}{32}" = 15\frac{11}{32}"$

8. $3 \times 9\frac{1}{2}h/d \times 2d =$ ~~=h~~

133h

9. $\frac{1.5\frac{3}{4}\ mA}{\frac{3}{8}\ mA} = 4$

10.

a. $I = \frac{1\frac{1}{2}V}{3\Omega} = \frac{1}{2}A$

b. $P = \frac{1}{2}A \times 1\frac{1}{2}V = \frac{3}{4}W$

11.

0.5625

12.

$\frac{5}{8}$

13.

$I_t = 0.38A + 0.09A + 0.142 =$

1.212 A

14.

500m - 37.8m - 65.14m - 11m - 41.08m = 344.98m

15.

$E_{rms} = 0.707 \times 25V_p =$

17.675 V

16.

$f = \frac{1}{0.0008_s} = 1250Hz$

17.

100Ω

18.

1/9

19.

256

20.

$\frac{9}{16}$

21.

25

22. $\frac{3}{4}$

23. 4Ω.

24. 2 in To 3

2 : 3 2 : 3

25. 1 : 5

26. 250

27. 3.81 cm

28. 2.355 in.

29. 130.35

30. 90.24%

31. 38.9 mA

32. 15 in.

33. 18 ft.

34.

2052

READING COMPREHENSION

1. a	10. c	19. radiated energy
2. d	11. b	20. Electro magnetic waves
3. b	12. a	21. b
4. c	13. d	22. c
5. b	14. ~~a~~	23. d
6. d	15. ~~c~~	24. c
7. c	16. b	25. b
8. b	17. b	
9. d	18. c	

SPELLING

1.
2.
3.
4.
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6.
7.
8.
9.
10.

RESOURCES

FORMULAS USED IN ELECTRONICS

The Electronics Technician survey instrument may be used in any of the following ways:

1) Pre-test, Post-test

2) Scope and sequence review of skills prior to entering an electronics technician course

3) Individualized study packet for self-learning, self-check

The Electronics Technician Survey was developed by Deanna Geffe, Carol Bement - Learning Resource Center Instructors and Chuck Ayling and Tom Macy - Electronics Technician Instructors at Lake Washington Vocational Technical Institute.

FORMULAS USED IN ELECTRONICS

$$E = I \times R$$

$$P = I \times E$$

$$I_T = I_1 + I_2 + I_3$$

$$\pi = 3.14$$

$$E_{RMS} = .707 \times E_P$$

$$P = I^2 R$$

$$F = 1/t$$

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$X_L = 2 \pi F L$$

$$X_C = \frac{1}{2 \pi F C}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{R^2 + X_L^2}$$

$$Z = \sqrt{R^2 + X_C^2}$$

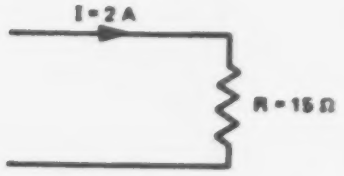
COMPUTER FIELD SERVICE TECHNICIAN
MATH AND READING SURVEY

1. An annual inventory requires that all of the resistors in stock be counted. During five days 3 825, 1 627, 2 874, 4 926, and 3 041 resistors are counted. Find the total number in stock.

2. A television repair technician receives checks for $126.58, $37.95, $95.73, and $258.08 for making repairs. The technician spends $328.00 for spare parts. Find the amount of money remaining.

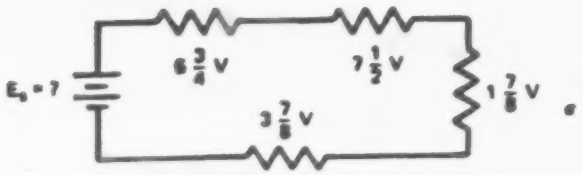
3. A delivery van travels at 82 kilometres per hour for 3.5 hours. The van averages 14 kilometres per gallon of gas. How many gallons of gas are used?

4. The resistor in this diagram draws a current of 2 A. Find the voltage drop across it.



5. A shipment of 4 550 diodes are separated into 14 boxes. How many diodes are in each box?

6. The sum of the voltage drops in a series circuit equals the source voltage (E_s). Use this circuit to find E_s.



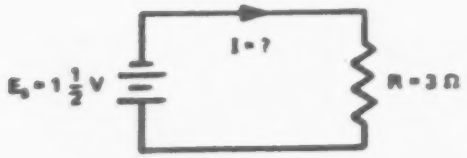
7. A piece of cable is 27 3/16 inches long. How many inches remain after 11 27/32 inches are cut off?

8. During the installation of a closed circuit television system 3 workers spend 9 1/2 hours per day for the first 2 days. On the third day another member joins the crew. The group works 9 1/2 hours per day for 2 more days. Find the total hours worked.

9. The current gain of an amplifier is found by dividing the output current by the input current. The input current is 3/8 mA and the output current is 15 3/4 mA. Find the current gain.

10. Use this circuit to find the indicated values.

Note: $I = E \div R$
$P = I \times E$



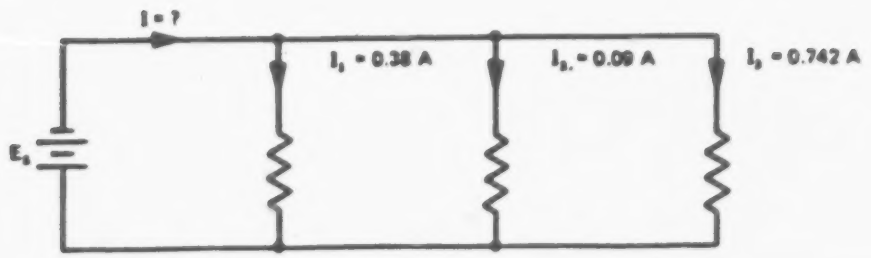
a. Find the current (I) in amperes.

b. Find the power (P) in watts.

11. Express 9/16 as a decimal.

12. Express 0.625 as a fraction in lowest terms.

13. What is the total resistance in this circuit?

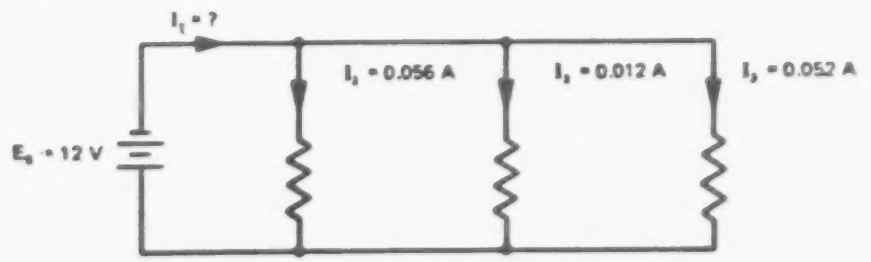


14. A technician has a roll of wire that is 500 m long. Pieces of 37.8 m, 65.14 m, 11 m, and 41.08 m long are cut off. How much wire is left?

15. Find the rms voltage of an AC signal with a 25-V peak.

16. Find the frequency of a signal, in hertz, with a period of 0.000 8 s.

17. Find the total circuit resistance in this circuit.



18. What is the value of 7^2?

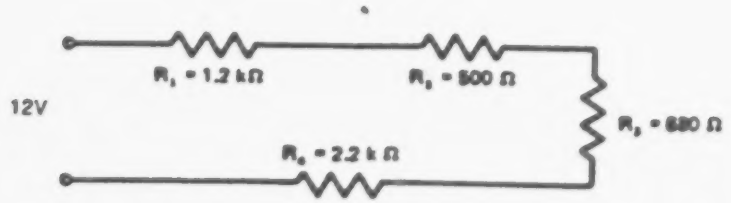
19. What is the value of 4^4?

20. What is the value of $(3/4)^2$?

21. Express 1.5 amperes as milliamperes.

22. An AM radio station broadcasts on 700 kHz. How many mHz is this equal to?

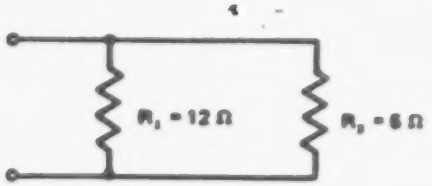
23. What is the total current in this circuit?



24. Find the square root of 625.

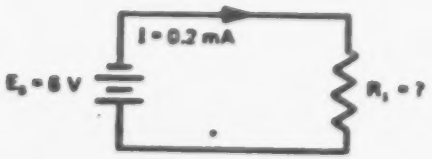
25. What is the value of $\sqrt{9/16}$?

26. Find total resistance.



27. A 5-kΩ resistor has a 15-V drop across it. What is the current flow, in milliamperes?

28. Calculate the value of R_1 in this circuit.



29. A load is connected to a 9-V battery and draws a current of 4.5 mA. Find the power consumed by the load.

30. A resistor is connected to a source voltage and consumes 2.88 W of power. The current is 0.12 A.

a. Find the source voltage.

b. Find the resistor value.

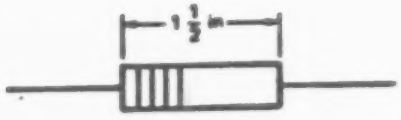
31. Express the ratio 12:18 in lowest terms.

32. Find the ratio of 2.2 kΩ to 11 000 Ω.

33. Calculate the missing quantity in the proportion 5:2 = x:100.

34. Find the length, in centimetres, of the resistor in this diagram.

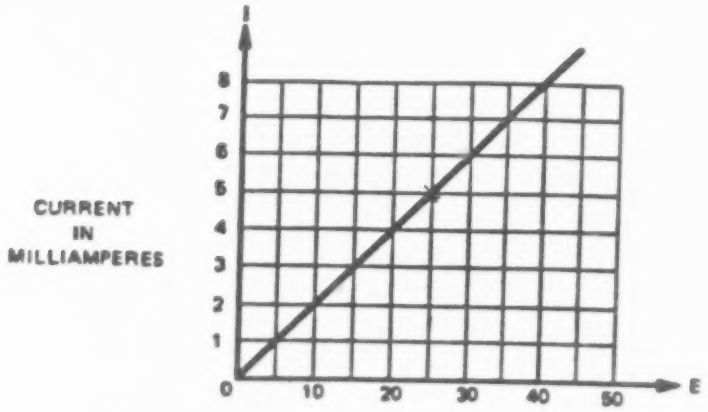
Note: 1 in = 2.54 cm



35. The base of a tube is circular and is 0.75 inches in diameter (d). Find the circumference (C).

Note: C = πd, where π = 3.14

36. Use this graph to determine the current, in milliamperes, when a voltage of 25 volts exists.



37. Find 82.5% of 158.

38. During a test 37 out of 41 turntables checked acceptable. What percent are acceptable? Express the answer to the nearer hundredth percent.

39. Find the average of 42 mA, 38.2 mA, 15.8 mA, 50.5 mA, and 48 mA.

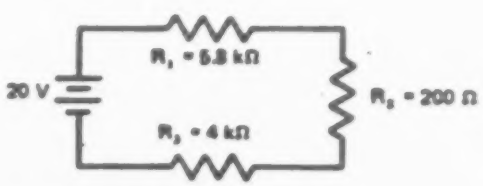
40. A resistor is color coded red, red, orange, and gold. What is the resistor value and its tolerance?

41. Use this series circuit to find these values.

a. R_t

b. I_t

c. E_{R_3}



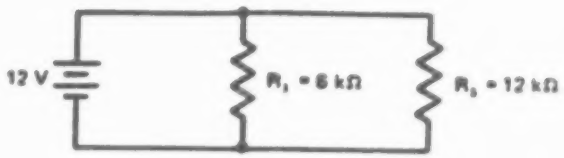
42. Find the indicated values for this parallel circuit.

a. R_t

b. I_t

c. I_{R_1}

d. I_{R_2}



43. Use this series-parallel circuit to find the values indicated.

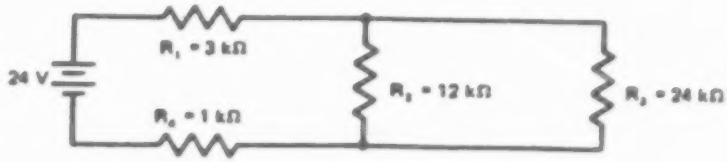
a. R_t

b. I_t

c. E_{R_1}

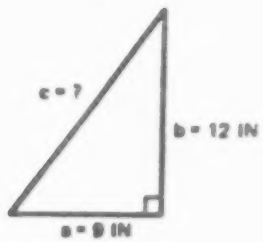
d. I_{R_3}

e. E_{R_4}



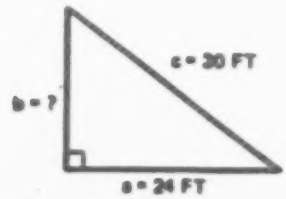
44. Find the length of the missing side in this right triangle.

Note: $c = \sqrt{a^2 + b^2}$



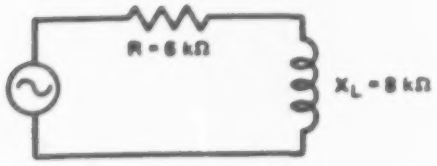
45. Calculate side b in this diagram.

Note: $b = \sqrt{c^2 - a^2}$



46. A 5-H coil is placed in a circuit operating at a frequency of 500 Hz. Find the inductive reactance in ohms, of this coil.

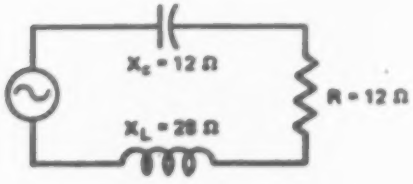
47. Calculate impedance in ohms, for this series RL circuit.



48. Find the capacitive reactance to the nearer tenth ohm, that a 1-μF capacitor has at a frequency of 4 kHz.

49. Use this series RC circuit to compute impedance in ohms.

50. Calculate impedance (Z), in ohms, for this series RCL circuit.



COMPREHENSION

Sample: Read the passage below.

> Joe decided to get a part-time job after school. He looked in the classified section of the newspaper since this part contains the help wanted notices. He found two companies near home which were hiring and called for an appointment for an interview.

Now read the item below.

The classified section of the newspaper contains

a. secret information
b. help wanted notices
c. current news stories
d. advice to the lovelorn

Look at the section of your answer sheet under the word Comprehension. Put a "b" on the line for the answer for the sample item because the classified section of the newspaper contains "help wanted notices."

Items 1-3 measure your knowledge of reference information.
Read each question and mark your answer on the answer sheet.

1. A glossary contains
   a. definitions
   b. quotes from famous people
   c. tables and diagrams
   d. an overview of the book
2. The appendix of a book consists of
   a. unusual words used in the text
   b. a list of chapter headings
   c. a list of authors
   d. supplementary material
3. A bibliography contains
   a. a list of important names and dates
   b. a list of books
   c. a list of topics covered in the text
   d. a list of words used in the text

Now read the Table of Contents on the next page. Answer the questions which follow.

TABLE OF CONTENTS

CHAPTER		PAGE
1.	Electricity—The Behavior of Electrons	1
2.	Electrical Circuits	22
3.	Electrical Energy & Power	41
4.	Electric Heating & Lighting	86
5.	Cells & Batteries	129
6.	Motors	154
7.	Amplifiers	221
8.	Safety in Electricity-Electronics Shops	235
9.	Careers in Electricity & Electronics	253

4. The chapter "Electric Heating & Lighting" begins on page
   a. 41 b. 68 c. 86 d. 129

5. Page 145 is in which chapter?
   a. "Motors"
   b. "Cells & Batteries"
   c. "Electrical Energy & Power"
   d. "Amplifiers"

6. Information on an occupation in electrical engineering can be found in which chapter?
   a. 1 b. 5 c. 7 d. 9

Read the Index. Then do items 7-9 and mark your answers on

INDEX

Charges, electric, defined, 3
laws of, 4
Circuit breakers, defined, 126-127
Clamps, cable, 147
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ground, 203
Codes, local, 92
Conductors, defined, 5
insulation, 97-98
joints, 111
sizes, 93-95
skin effects on, 95-96
soldering, 110-111

7. The meaning of the word "conductor" is on page
   a. 3
   b. 4
   c. 5
   d. 111

8. The local electrical codes can be found on page
   a. 203
   b. 92
   c. 93
   d. 147

9. The effects of conductors on the skin begins on page
   a. 161
   b. 5
   c. 93
   d. 95

95

Read the passages. After each passage, choose the best answer for each item and mark your answer on the answer sheet.

For a rough classification, magnets may be divided into two groups: permanent or temporary. A permanent magnet is intended to keep its atomic arrangement steady after the magnetizing force is removed. Permanent magnets are used in telephone receivers, door latches, small d.c. motors, electrical measuring instruments, magnetos, speedometers, and a great variety of gadgets. For years, high-carbon tool steel, and a few alloy steels (cobalt, molybdenum, chrome-tungsten) were the only useful permanent magnet materials. Later, various alloys were developed, such as Alnico (aluminum, nickel, cobalt, iron), which is widely used as a high-strength permanent magnet. Flexible rubbery magnets are made by mixing magnetic oxide powders with vinyl and other plastics.

Temporary-magnet materials, which are easily and strongly magnetized but lose most of their strength when the magnetizing force is removed, are of more importance than permanent-magnet materials, both in total amount in use and in variety of applications. The first-used material for temporary magnets was plain iron, as pure as could be obtained, softened by annealing (slow cooling). A soft metal is one in which atoms slide around readily, permitting atoms to be magnetically disarranged easily. The most-used material is silicon iron (2-4% Si), a soft alloy used in transformers, most motors and generators, relays and other magnetic equipment built in large quantities.

Answer questions 10-13.

10. The best title for this selection is
    a. "Temporary Magnets"
    b. "Permanent Magnets"
    c. "Types of Magnetic Materials"
    d. "Electromagnetic Force"

11. As used in this passage, the term "annealing" means
    a. fast cooling
    b. slow cooling
    c. easily magnetized
    d. softening

12. Which of the following is not a permanent magnet material?
    a. silicon
    b. high-carbon tool steel
    c. alloy steel
    d. Alnico

13. Temporary magnets are used in
    a. telephone receivers
    b. door latches
    c. speedometers
    d. transformers

Read the passage on the following page and answer questions 14-16.

To use an ohmmeter, the tips of the test leads are first held together (short-circuited) and the rheostat adjusted so that the pointer of the meter moves over to the righthand end of the scale, where the "zero ohms" mark is placed. The meter now indicates that there is zero resistance between the test leads.

When the test leads are separated, there is no current in the circuit, and the pointer drops back to the left end of the scale, where the "infinity ohms" mark is placed.

When the test leads are touched to the ends of a resistor of unknown value, the resistance is read directly from the "ohms" scale. Normally, an ohmmeter has several ranges, with different combinations of series resistance and battery voltage used in each range.

The ohmmeter diagrammed in Fig. 7-10 is called a series ohmmeter, and is usually installed in a case containing multiple-contact switches, voltmeter resistors, and ammeter shunts, forming the "multimeter" or "volt-ohmmeter" that is widely used in testing electronic equipment.

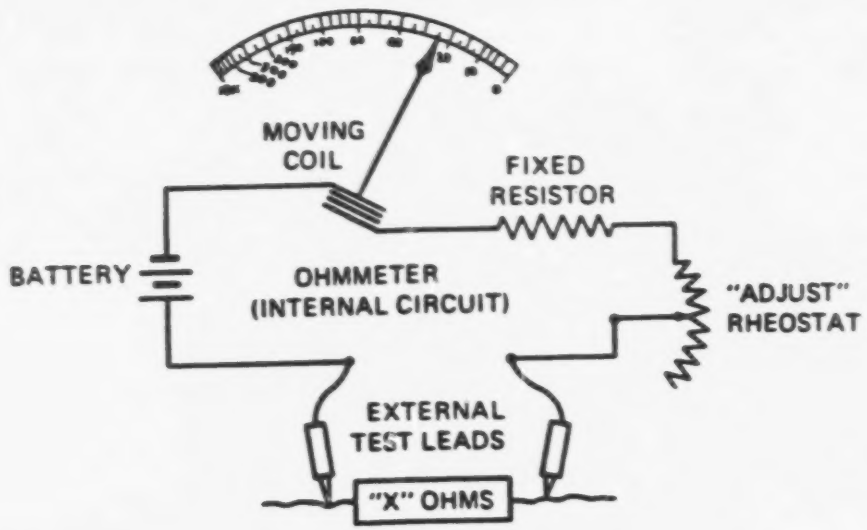


Fig. 7-10 Ohmmeter Circuit

14. To use an ohmmeter, the rheostat must first be set at
    a. zero b. infinity c. 10 ohms d. 10 K ohms
15. The following steps are used to measure resistance in a circuit. Which step is taken first?
    a. connect ohmmeter
    b. discharge electrolytic capacitors
    c. turn off power
    d. read "ohm" scale
16. When there is no current in a circuit, what is the reading on the ohmmeter scale?
    a. zero b. infinity c. 10 ohms d. 100 ohms

Read the passage on the following page and answer questions 17-20. Put your answers on the answer sheet.

Light is energy that is radiated by electronic disturbances in atoms. Electrons in an atom can accumulate energy in many ways: from heat, as in a red-hot object; or by being hit by other electrons, as in a gas-conduction tube; or by absorbing energy radiated by other materials. Sooner or later, this absorbed energy is given out. The amount of energy that an electron can get rid of in one burst depends on where the electron is, that is, what kind of atom it is in, and its location in the atom.

The energy is radiated as a wave-like pulse of electric lines of force and magnetic lines of force, which is called an electromagnetic wave. The vibration frequency of these traveling lines of force is proportional to the amount of energy that the electron gave off. Frequencies in the range from 4.3×10^{14} to 7.5×10^{14} vibrations per second affect electrons in our eyes. We call electromagnetic waves in this frequency range by the name of "light."

Waves of a frequency slightly higher than 7.5×10^{14} are called "ultra-violet," waves in a lower frequency range, from 10^{11} to 10^{14} vibrations per second are called "infra-red," and heat radiation. The term "black light," often used by newspaper reporters who do not know the correct terms, may mean either ultra-violet or infra-red. Ultra-violet and infra-red differ greatly in their effects and uses.

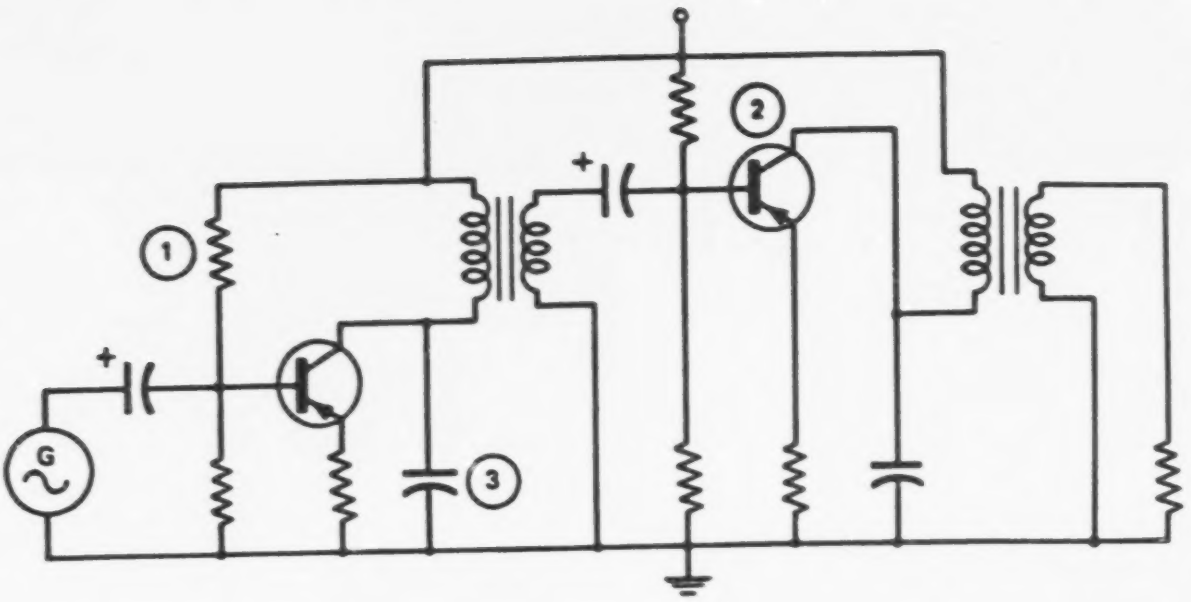
17. The best title for this passage is
    a. "How Light Is Measured"
    b. "What Is Light?"
    c. "Sources of Light"
    d. "Commercial Light Sources"

18. Which of the following is not one of the ways electrons in an atom accumulate energy?
    a. by being hit by other electrons
    b. by absorbing energy radiated by other materials
    c. from cooling temperatures
    d. from heat

19. Define "light"

20. Define "light" a second way

On the following page you will find a diagram. Use the diagram to answer questions 21-23. Mark your answers on the answer sheet.



21. Find 1 on the diagram. This symbol refers to a
    a. capacitor
    b. resistor
    c. transformer
    d. battery

22. Find 2 on the diagram. This symbol refers to a
    a. diode
    b. transistor, NPN
    c. transistor, PNP
    d. thermocouple

23. Find 3 on the diagram. This symbol refers to a
    a. battery
    b. generator
    c. dry cell
    d. capacitor

Use the Table of Natural Sines and Cosines to answer questions 24-25.

NATURAL SINES AND COSINES

NOTE: For cosines, use right-hand columns of degrees and lower line of tenths.

Deg.	°0.0	°0.1	°0.2	°0.3	°0.4	°0.5	°0.6	°0.7	°0.8	°0.9	°1.0	
45	0.7071	0.7083	0.7096	0.7108	0.7120	0.7133	0.7145	0.7157	0.7169	0.7181	0.7193	44
46	0.7193	0.7206	0.7218	0.7230	0.7242	0.7254	0.7266	0.7278	0.7290	0.7302	0.7314	43
47	0.7314	0.7325	0.7337	0.7349	0.7361	0.7373	0.7385	0.7396	0.7408	0.7420	0.7431	42
48	0.7431	0.7443	0.7455	0.7466	0.7478	0.7490	0.7501	0.7513	0.7524	0.7536	0.7547	41
49	0.7547	0.7559	0.7570	0.7581	0.7593	0.7604	0.7615	0.7627	0.7638	0.7649	0.7660	40
50°	0.7660	0.7672	0.7683	0.7694	0.7706	0.7716	0.7727	0.7738	0.7749	0.7760	0.7771	39
51	0.7771	0.7782	0.7793	0.7804	0.7815	0.7826	0.7837	0.7848	0.7859	0.7869	0.7880	38
52	0.7880	0.7891	0.7902	0.7912	0.7923	0.7934	0.7944	0.7955	0.7965	0.7976	0.7986	37
53	0.7986	0.7997	0.8007	0.8018	0.8028	0.8039	0.8049	0.8059	0.8070	0.8080	0.8090	36
54	0.8090	0.8100	0.8111	0.8121	0.8131	0.8141	0.8151	0.8161	0.8171	0.8181	0.8192	35
55	0.8192	0.8202	0.8211	0.8221	0.8231	0.8241	0.8251	0.8261	0.8271	0.8281	0.8290	34
56	0.8290	0.8300	0.8310	0.8320	0.8329	0.8339	0.8348	0.8358	0.8368	0.8377	0.8387	33
57	0.8387	0.8396	0.8406	0.8415	0.8425	0.8434	0.8443	0.8453	0.8462	0.8471	0.8480	32
58	0.8480	0.8490	0.8499	0.8508	0.8517	0.8526	0.8536	0.8545	0.8554	0.8563	0.8572	31
59	0.8572	0.8581	0.8590	0.8599	0.8607	0.8616	0.8625	0.8634	0.8643	0.8652	0.8660	30
60°	0.8660	0.8669	0.8678	0.8686	0.8695	0.8704	0.8712	0.8721	0.8729	0.8738	0.8746	29
61	0.8746	0.8755	0.8763	0.8771	0.8780	0.8788	0.8796	0.8805	0.8813	0.8821	0.8829	28
62	0.8829	0.8838	0.8846	0.8854	0.8862	0.8870	0.8878	0.8886	0.8894	0.8902	0.8910	27
63	0.8910	0.8918	0.8926	0.8934	0.8942	0.8949	0.8957	0.8965	0.8973	0.8980	0.8988	26
64	0.8988	0.8996	0.9003	0.9011	0.9018	0.9026	0.9033	0.9041	0.9048	0.9056	0.9063	25
65	0.9063	0.9070	0.9078	0.9085	0.9092	0.9100	0.9107	0.9114	0.9121	0.9128	0.9135	24
66	0.9135	0.9143	0.9150	0.9157	0.9164	0.9171	0.9178	0.9184	0.9191	0.9198	0.9205	23
67	0.9205	0.9212	0.9219	0.9225	0.9232	0.9238	0.9245	0.9252	0.9259	0.9265	0.9272	22
68	0.9272	0.9278	0.9285	0.9291	0.9298	0.9304	0.9311	0.9317	0.9323	0.9330	0.9336	21
69	0.9336	0.9342	0.9348	0.9354	0.9361	0.9367	0.9373	0.9379	0.9385	0.9391	0.9397	20°
70°	0.9397	0.9403	0.9409	0.9415	0.9421	0.9426	0.9432	0.9438	0.9444	0.9449	0.9455	19
71	0.9455	0.9461	0.9466	0.9472	0.9478	0.9483	0.9489	0.9494	0.9500	0.9505	0.9511	18
72	0.9511	0.9516	0.9521	0.9527	0.9532	0.9537	0.9542	0.9548	0.9553	0.9558	0.9563	17
73	0.9563	0.9568	0.9573	0.9578	0.9583	0.9588	0.9593	0.9598	0.9603	0.9608	0.9613	16
74	0.9613	0.9617	0.9622	0.9627	0.9632	0.9636	0.9641	0.9646	0.9650	0.9655	0.9659	15
75	0.9659	0.9664	0.9668	0.9673	0.9677	0.9681	0.9686	0.9690	0.9694	0.9699	0.9703	14
76	0.9703	0.9707	0.9711	0.9715	0.9720	0.9724	0.9728	0.9732	0.9736	0.9740	0.9744	13
77	0.9744	0.9748	0.9751	0.9756	0.9759	0.9763	0.9767	0.9770	0.9774	0.9778	0.9781	12
78	0.9781	0.9785	0.9789	0.9792	0.9796	0.9799	0.9803	0.9806	0.9810	0.9813	0.9816	11
79	0.9816	0.9820	0.9823	0.9826	0.9829	0.9833	0.9836	0.9839	0.9842	0.9845	0.9848	10°
80°	0.9848	0.9851	0.9854	0.9857	0.9860	0.9863	0.9866	0.9869	0.9871	0.9874	0.9877	9
81	0.9877	0.9880	0.9882	0.9885	0.9888	0.9890	0.9893	0.9895	0.9898	0.9900	0.9903	8
82	0.9903	0.9905	0.9907	0.9910	0.9912	0.9914	0.9917	0.9919	0.9921	0.9923	0.9925	7
83	0.9925	0.9928	0.9930	0.9932	0.9934	0.9936	0.9938	0.9940	0.9942	0.9943	0.9945	6
84	0.9945	0.9947	0.9949	0.9951	0.9952	0.9954	0.9956	0.9957	0.9959	0.9960	0.9962	5
85	0.9962	0.9963	0.9965	0.9966	0.9968	0.9969	0.9971	0.9972	0.9973	0.9974	0.9976	4
86	0.9976	0.9977	0.9978	0.9979	0.9980	0.9981	0.9982	0.9983	0.9984	0.9985	0.9986	3
87	0.9986	0.9987	0.9988	0.9989	0.9990	0.9990	0.9991	0.9992	0.9993	0.9993	0.9994	2
88	0.9994	0.9995	0.9995	0.9996	0.9996	0.9997	0.9997	0.9997	0.9998	0.9998	0.9998	1
89	0.9998	0.9999	0.9999	0.9999	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0°
	°1.0	°0.9	°0.8	°0.7	°0.6	°0.5	°0.4	°0.3	°0.2	°0.1	°0.0	Deg.

24. What is the natural sine of a 57.3° angle?

a. 0.8508
b. 0.8453
c. 0.8415
d. 0.8320

25. What is the natural cosine of a 28.4° angle?

a. 0.8780
b. 0.8796
c. 0.8878
d. 0.8805

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VOCABULARY

DIRECTIONS: Look at the sample test word below. The word is *battery*. Now read the definitions just below *battery*. Find the one definition in this group that means most nearly the same as *battery*. Definition "b" is the correct definition, "an electro-chemical device for producing electricity." On your answer sheet, under the section marked Vocabulary, find the line marked "Sample" and write a "b" on that line.

For each numbered word in this section, write the letter of the definition that means most nearly the same as the given word on your answer sheet. If you are not sure of an answer, make the most careful guess you can.

Sample: battery

a. a replaceable cylinder
b. an electrochemical device for producing electricity
c. device found only in a car or truck
d. device for changing electrical energy into chemical energy
e. none of the above

1. volt
   a. practical unit of resistance
   b. practical unit of electric current
   c. practical unit of electromotive force
   d. practical unit of electrical power
   e. none of the above

2. current
   a. flow of electrons
   b. popular
   c. instrument used to measure heat
   d. unit of measurement
   e. none of the above

3. ammeter
   a. unit of length
   b. instrument used to measure resistance
   c. unit of weight
   d. instrument used to measure current
   e. none of the above

4. generator
   a. device found only in a car or truck
   b. device that converts mechanical energy into electrical energy
   c. an instrument which measures heat
   d. device that changes electrical energy into mechanical energy
   e. none of the above

5. resonance
   a. property of batteries
   b. ability of material to produce sound
   c. ability of material to produce electricity
   d. that adjustment of a current which allows the greatest flow of current of a certain frequency
   e. none of the above

6. Ohm
   a. device used to measure current
   b. unit of measure of resistance
   c. unit of measure of current
   d. instrument used to measure length
   e. none of the above

7. resistance
   a. ability of material to withstand the flow of electrons
   b. ability of material to encourage the flow of electrons
   c. ability of material to convert neutrons to electrons
   d. ability of material to convert protons to electrons
   e. none of the above

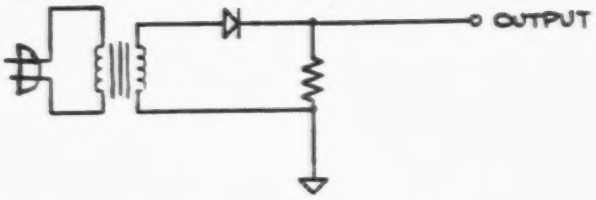
8. ground
   a. bottom of a generator
   b. connection of an electrical conductor with the earth
   c. lowest part of a motor
   d. another name for current
   e. none of the above

9. circuit
   a. device which directs the flow of atoms
   b. complete path along which electrons can move
   c. a coil of wire
   d. a type of conductor
   e. none of the above

10. capacitor
   a. instrument to measure amount something can hold
   b. two insulators separated by a conductor
   c. two conductors separated by an insulator
   d. device which measures electric current
   e. none of the above

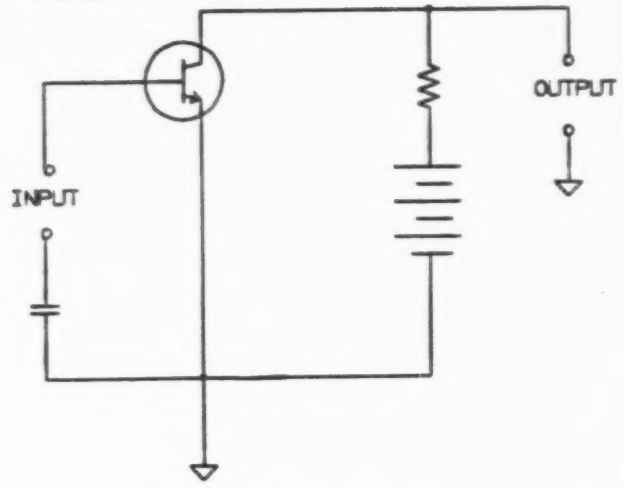
ELECTRONICS

1. IDENTIFY THE FOLLOWING CIRCUIT



A. FULL WAVE RECTIFIER
B. BRIDGE RECTIFIER
C. HALF-WAVE RECTIFIER
D. SQUARE-WAVE RECTIFIER

2. THE DIAGRAM REPRESENTS

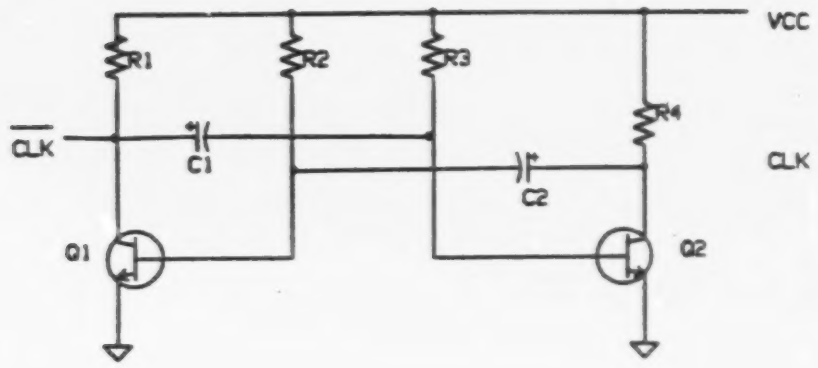


A. CB AMPLIFIER
B. CE AMPLIFIER
C. CC AMPLIFIER
D. EMITTER-FOLLOWER AMPLIFIER

3. THE FOLLOWING REPRESENTS

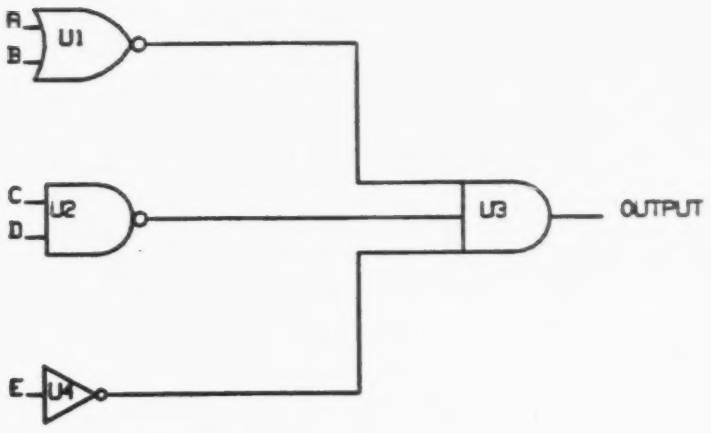
A. ZENER DIODE
B. TUNNEL DIODE
C. LED
D. RECTIFIER DIODE

4. IN THE FOLLOWING CIRCUIT WHAT COMPONENTS CONTROL THE FREQUENCY OF OSCILLATION



A. R1, R2, R3, R4
B. R2, R3, Q1, Q2,
C. R2, R3, C1, C2,
D. R1, R4, C1, C2,

5. WHAT IS THE OUTPUT OF THE FOLLOWING LOGIC CIRCUIT ?



A. $\overline{A + B \cdot C \cdot D \cdot E}$
B. $A \cdot B + C \cdot D + E$
C. $A + B \cdot C \cdot D \cdot E$
D. $\overline{A \cdot B} + \overline{C \cdot D} + \overline{E}$

SURVEY ANSWER SHEET

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MATH

1. 16,293
2. 190.34
3. 20.5
4. 30 V
5. 325
6. 20 V
7. 15 11/32 in
8. 133 h
9. 42
10. a. 1/2 A
    b. 3/4 W
11. .5625
12. 5/6
13. emit
14. 344.98
15. 17.675 V
16. 1250 Hz
17. 100 Ω
18. 49
19. 256
20. 9/16
21. 1500 mA
22. .7 MHz
23. .00262 A (or) 2.62 mA
24. 25
25. 3/4
26. 4 Ω
27. 3 mA
28. 30 KΩ
29. 40.5 mW
30. a. 24 V
    b. 200 Ω
31. 2:3
32. 1:5
33. 250
34. 3.81 cm
35. 2.355 in
36. 5 mA
37. 130.35
38. 90.24%
39. 38.9 mA
40. 22 KΩ; 5%
41. a. 10 KΩ
    b. 2 mA
    c. 8 V
42. a. 4 KΩ
    b. 3 mA(er) .003 H
    c. 2 mA(er) .002 A
    d. 1 mA(er) .001 H
43. a. 12 KΩ
    b. 2 mA
    c. 6 V
44. .67 mA
    e. 2 V
45. 15 in
    18. Ft.
46. 15.700 Ω
47. 10 KΩ
48. 39.8 Ω
49. 25 KΩ
50. 20 Ω

READING COMPREHENSION

1.	a	13.	d
2.	d	14.	a
3.	b	15.	c
4.	c	16.	b
5.	b	17.	b
6.	d	18.	c
7.	c	19.	radiated energy
8.	b	20.	electromagnetic waves
9.	d	21.	b
10.	c	22.	c
11.	b	23.	d
12.	a	24.	c
		25.	b

VOCABULARY

1.	c	6.	b
2.	a	7.	a
3.	d	8.	b
4.	b	9.	b
5.	d	10.	c

1. C
2. B
3. A
4. C
5. A

SPELLING

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

SURVEY ANSWER SHEET

MATH

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. a. _____
    b. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____
24. _____
25. _____
26. _____
28. _____
29. _____
30. a. _____
    b. _____
31. _____
32. _____
33. _____
34. _____
35. _____
36. _____
37. _____
38. _____
39. _____
40. _____
41. a. _____
    b. _____
    c. _____
42. a. _____
    b. _____
    c. _____
    d. _____
43. a. _____
    b. _____
    c. _____
    d. _____
    e. _____
44. _____
46. _____
47. _____
48. _____
49. _____
50. _____

READING COMPREHENSION

1. _____
2. _____
3. _____
4. _____
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6. _____
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15. _____
16. _____
17. _____
18. _____
19. _____
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21. _____
22. _____
23. _____
24. _____
25. _____

VOCABULARY

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

1. 2.

3. 4.

SPELLING

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

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